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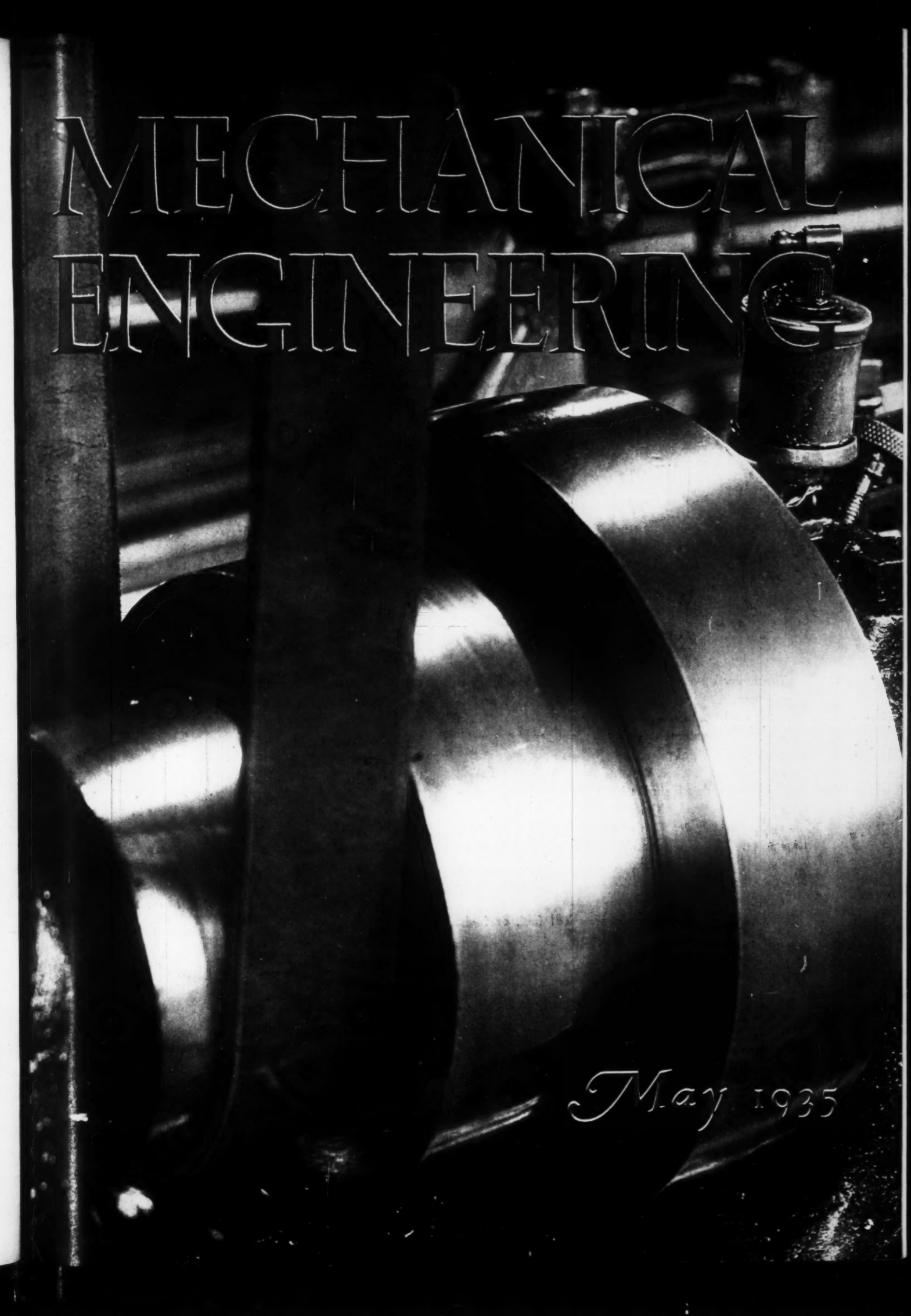

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MECHANICAL ENGINEERING

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VOLUME 57 NUMBER 5

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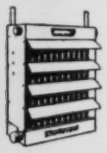

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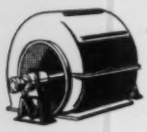

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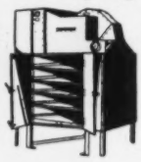

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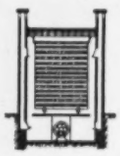

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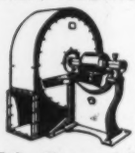

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VOLUME 57
No. 5

MECHANICAL ENGINEERING

MAY
1935

GEORGE A. STETSON, *Editor*

Richard Mollier

FOR at least a quarter of a century every student of thermodynamics has studied, used, and learned to admire the Mollier diagram. No less distinguished an authority than the late Sir Alfred Ewing said of it that it possessed "advantages that entitle it to first place among devices for representing graphically the thermodynamic advantages of steam engines, or of the working fluids in refrigerating engines."

While any two of a number of properties of steam may be used effectively as coordinate axes for representing innumerable processes of importance using steam or other vapors, the Mollier diagram, from which differences in total heat content can be so readily determined for any conditions of moisture or superheat, has undoubted utility. Even when it is not drawn to accurate scale, the chart provides a ready means of representing graphically a variety of processes and cycles so clearly that economy of effort in explanation on the one hand and in comprehension on the other are secured.

Richard Mollier, of Dresden, who first published this useful device in 1904, died on March 14, 1935. Engineers will continue to honor his memory by associating his name with the total-heat-entropy diagram whenever it is used.

A Useful Registration

THE dislocations and changes brought about by the world-wide depression have made necessary a resurvey of the membership of The American Society of Mechanical Engineers in order to bring up to date and place in useful form personal and professional data relating to every member. Hence members have received in the mail a four-page record blank to be filled out and returned to headquarters as soon as possible.

The value and principal uses to which the information reported on the blanks may be put are evident at a glance. Pages one, three, and four, for example, are devoted to biographical and professional data desired in any complete history file. From these the characteristics and attainments of every individual can be determined. Such information is valuable in making appointments to committees and in finding the man best suited for particular jobs that come day by day to the secretary's office.

Page two, if carefully checked, should reveal a member's professional interests so completely that the program-making agencies of the Society may find the particular subjects in which there is abundant interest and the individuals who are likely to benefit from activities carried on in these fields.

Returns from the first mailing have indicated a willingness on the part of members to supply the Society with this complete information about themselves and their professional records. The result at headquarters has been to endow each of these members with a distinctive individuality, more accurate, in many cases, than personal acquaintanceship, which is necessarily limited to a relatively few, can ever be. It is the desire and intention of the headquarters staff to make abundant and constant use of the records obtained in service to the members so recorded. From them it is hoped new and valuable material for Society work will be recruited, and many unknown but able experts in a variety of fields will be discovered. When the request comes for an unusual man to fill an important job, information will be available on hundreds of members, and the Secretary's office will not have to rely upon the chance recollection of some one recently come to its attention. Thus by a fuller knowledge of what a mechanical engineer is like and what he has accomplished, greater coordination in Society work and service may be expected. Every member can help in this useful work by filling out the blank as completely as possible and returning it promptly for classification and filing.

Portrait of Parsons

TO ENGINEERS the name of Parsons is as imperishably associated with the steam turbine as the name of Watt is with the steam engine. But what manner of man he was probably a majority of engineers in this country have had little occasion to discover except from the addresses which he made before learned societies and from the familiar portrait which betrays a keen intelligence and thoroughly aroused interest. We have reason to be grateful, therefore, to the more intimate picture of the man sketched in words by one who knew him well, Lord Rayleigh. For none can read the memoir that he has prepared to the scientific papers and addresses of the Hon. Sir Charles A. Parsons, recently published by the Cambridge University Press, without chuckling over the little incidents brought to light in such friendly fashion.

Lord Rayleigh describes, for example, the "sanctum not without distinction" at Ray, the Parsons shooting lodge on the Northumberland moors. A sanctum it was, and a man's at that, which house-maids must not disturb and from which Lady Parsons herself might sometimes remove "cigarette ends, burnt-out matches, and the like." More expressive it was, apparently, of the man than of the engineer and inventor, for Lord Rayleigh notes little that might be significant of Parsons' work though much that, in the total of its details, could belong to no one but the man himself.

By deft touches of anecdote, Lord Rayleigh makes a person out of a name. He tells about the "criticism in emphatic language" called out by Parsons, the automobilist, to other drivers on the road; the white cockatoo, inhabitant of the sanctum, that had to be placated in the midst of conversation with soothing words and sugar; the ingenious means of warming a too-cold carburetor; the parlor-maid's stays from whence came the steel spring to repair the distributor of the motor car; the relish with which the inventor unwittingly ate the dog's dish at breakfast; and a host of other trivialities and glimpses of Parsons at work and among his friends, until it becomes so real that we almost expect to look up and see the man himself standing there.

Too many of us think of men like Parsons as though they were the machines to which their names have become attached. But apparently the long static-looking turbine casing, with the rapidly turning rotor within responding so perfectly to the genius of the designer, is an inaccurate characterization of a man who professed to scorn analytical mechanics and made up his models out of paper, knitting needles, wax, and string; who cast longing eyes at his wife's engagement ring during the many years that he experimented on producing artificial diamonds; and who proposed the sinking of an enormous bore hole into the earth in order to find out what it might contain.

The papers on the steam turbine and related subjects, and the addresses which showed such a clear reading of the history and philosophy of invention are the valued writings that Parsons himself contributed to the literature of engineering. The memoir by Lord Rayleigh helps us to appreciate with a warmer sense of reality the essentially human characteristics of a man of genius. We can afford to think better of the human race knowing such men are parts of it, and we realize more fully the debt of engineering to them.

Men like Parsons are dissatisfied with the world as they find it, they work prodigiously, and they leave it better than they found it. Their lives are not easy. As Lord Rayleigh says "The young inventor in the commercial world is often regarded as a sort of revolutionary who wishes to upset vested interests, and many people's hands will at first be against him. Like a political revolutionary, he is apt to be regarded as a dangerous nuisance before he succeeds, and only becomes a hero afterwards." But without them there is little progress. Since the time of Watt we have seldom needed so desperately men with Parsons' abilities.

Dams—And What's Back of Them

THE present Administration will be known for a long time for the size and number of dams it has constructed. Wherever a river rolls limpidly or turbulently to the sea, the hand of man has been raised against it to check its course. A variety of excuses and explanations are offered—hydroelectric power, navigation, flood control, reclamation, irrigation, water supply—singly or in any combination. Pump-priming, recovery, relief of unemployment, socialization of areas inadequately supporting the underprivileged, yardsticks, decentralization, social planning, and dozens of other formulas lie conveniently at hand for the confounding and shaming of critics. That the engineering quality of these works is of a high order is attested, for example, by the extensive articles on the Boulder dam which ran through many of our issues in 1934. Courage, skill, and ingenuity for which engineers are justly famous are being abundantly displayed in these numerous works.

But genuine as is our admiration for the great dams that are rising across our rivers from coast to coast, there are other dams which should be removed. There are, for example, those obstructions in the regular channels of trade, commerce, and communication which interrupt the flow of goods and services in our economic life. In the construction of these dams the hand of the engineer is absent, and on him in particular neither blame nor credit can be placed. Back of these dams there are piling up great floods of unsatisfied wants, deferred plans, thwarted ambitions, and unfulfilled hopes that represent more of the good things of life to the inhabitants of this country than can ever be supplied by the benefits to be derived from steel and concrete structures financed by the Administration. Behind these dams is business.

In an effort to show for a certain group of industries of which it is constituted the extent of the flood of business that waits on "a sound governmental policy and restored confidence" the Machinery and Allied Products Institute has recently issued a report on its Potential Machinery Requirements Survey. Because the report will probably appear in a number of places, and because our own pages are too crowded to present it in full, only the high points will be commented on here.

The Survey was made through members of the 58 trade associations affiliated with M.A.P.I. From the data collected, the potential machinery requirements of all industry were found to be in excess of 18 billion dollars, distributed as follows: Agricultural implements, 3.94 per cent; electrical machinery, apparatus, etc., 32.63; engines, turbines, tractors, and water wheels, 6.48; foundry and machine-shop products, 39.30; machine tools, 3.9; and all others 13.75 per cent.

Attacking the problem from another point of view the report points out that with an annual machinery production of $6,609,500,000 prior to the depression, and an average annual production throughout the five years of the depression of only $2,737,500,000, the pent-up business would amount to 19 billion dollars, slightly in excess of the figure obtained by the survey.

A table of the potential machinery requirements of the builders of machinery in the 58 industries affiliated with M.A.P.I. shows a total of $45,377,402, of which 68.65 per cent is for machine tools, 7.34 per cent for electrical equipment, 5.37 for handling and service, 5.53 for power plant and boilers, and 13.11 for other machinery. Of the total, slightly more than half represents replacement.

Additional evidence of what is behind the dams of restricted business is offered in the March 30 issue of *Electrical World*. Basing its philosophy on recovery through private initiative the *World* states that "if encouraged, instead of destroyed, the public utilities can, with the help of other branches of the industry, create now a business of $16,500,000,000, employ 1,000,000 men, and add $1,000,000,000 a year to payrolls."

For engineers who have, during the past five years, had to content themselves with restricted outputs, and, in many cases, actual loss of job and means of livelihood, the potential markets for machinery, given "a sound governmental policy and restored confidence," the basis of the M.A.P.I. figures, and the expansion of public welfare that the public utilities may be able to stimulate "if encouraged instead of destroyed," are eagerly awaited. Rejuvenated business and jobs and satisfactions for mechanical engineers lie back of the dams that are holding up recovery.

The Thirty-Hour Week

THAT sooner or later the thirty-hour week will come there can be scarcely any doubt. In fact, with the progressive automatization of production there is no reason to believe that we are going to stop at thirty hours. The day may come, perhaps within the span of life of the present generation, when two or three days of work per week will be all that will be required for a better and fuller life than we enjoy today. When we consider, however, the problem of a thirty-hour week, as at present proposed, we are dealing not with what may happen in ten, twenty, or thirty years, but with the immediate present, with all of its social and economic deficiencies and maladjustments.

If the thirty-hour week is to be adopted in order to spread employment, there are probably enough men looking for work to satisfy many of the demands on labor that the shortening of the week may require. But who is going to pay for it? And how?

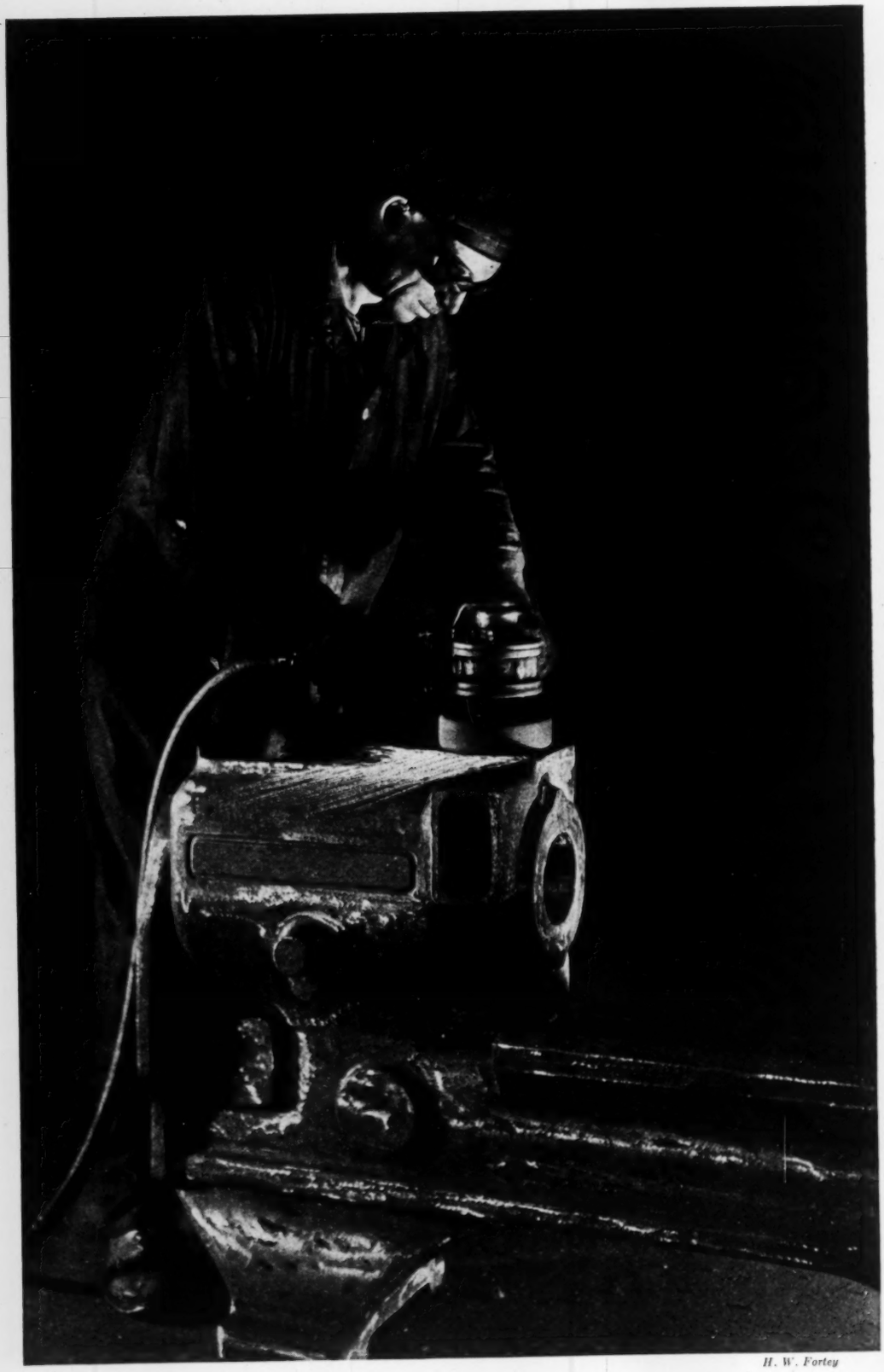
One way is to cut salaries and wages in proportion to hours. This has been tried in the "share-a-job" movement, adopted by some industries in the early years of the depression, and must be considered a purely emergency measure, which today would not be acceptable to any one, as it would merely freeze the present conditions rather than provide a basis for their improvement.

Another way is to cut the hours per week and at the same time speed up production, retaining the salaries and wages as they were before. Under this system labor would earn in thirty hours the same amount that it is earning today in forty to forty-eight hours, and would produce in accordance with its earnings. Labor would gain a few hours of leisure but there would be few possibilities of new employment. In many industries such a speeding up could not be achieved at all, or would be accompanied by excessive strain on labor, and in some cases a lowering of standards of safety. At best industry would have to reorganize itself to meet the more rapid tempo of production. There would be a tendency to introduce labor-saving devices so as to accomplish in six hours per day more than was formerly accomplished in seven or eight, and in general a number of difficult problems of control would have to be solved without any visible benefit to any one concerned.

Another possibility which is apparently in the back of the minds of those who are advocating the thirty-hour week is to take the difference between the cost of production under a forty- or forty-eight-hour week and the thirty-hour week out of the profits of capital. This might be nice for labor, though whether it would benefit the country as a whole still remains to be seen. It is not necessary, however, to give this possibility extensive consideration, as from corporation reports we know that the number of those out of the red is not large and the number of those that are in the black enough to meet the additional costs of production is extremely small.

Borrowing out of capital to pay a share of the costs of current production can be an emergency measure only. If an attempt should be made to use this scheme as a permanent device, capital would soon be exhausted and a complete collapse of national economy would follow. This is practically what happened in Germany after the Ruhr occupation by France, and is obviously inevitable, first because the amount of capital available even in such a wealthy country as the United States is limited, and second, because accumulation of capital is necessary to promote new industries without which a highly industrialized country like this cannot exist.

It should be noted that the proposals for the thirty-hour week have happily been restricted to industrial labor. No attempt has been made to extend the idea to workers on farms, to mothers and housewives, to creative scholars and scientists, or to the individuals and executives upon whose shoulders the real responsibility of maintaining and advancing the status of mankind rests. Furthermore, unless means are devised whereby the production of wealth can be made greatly more abundant, as by improved machinery, products, methods, and management, working men themselves will not be content, in times when employment is open to them, to limit their incomes by working thirty hours if there is a possibility of earning more by working longer hours at the same or a greater rate. But a workman who will be content with what he can earn in thirty hours when the possibility of earning more presents itself is not to be encouraged, and a social policy which tells him he may not earn more invades his rights as an individual and will result in the retrogression of the nation that adopts it. A civilization satisfied with a minimum, content to establish its economy on a poverty level, will have to give way eventually to a more virile type.



H. W. Fortey

Cleaning the Casting

PERSONALITY EVALUATION *and* BUSINESS RELATIONS

By ROY M. DORCUS

THE JOHNS HOPKINS UNIVERSITY

THE SPEAKERS who have preceded me in this series[1] have pointed out the importance of personal relationship in successful business adjustments. There is scarcely a job in which the social relations of the individual do not have not only an important bearing on his own immediate position but also upon the business organization which he represents. Therefore, my main thesis will be concerned with psychological attempts to define and measure personality.

The measurement of personality cannot be overemphasized. We are prone to make mistakes in judgment because (1) the essential factors for making the judgment are lacking; (2) the time required is inadequate; (3) the signs on which the judgment is based are erroneous; or (4) we do not have a clear-cut idea of what the concept signifies. Psychologists and others, therefore, have attempted to develop a suitable definition for personality, and have attempted to rule out in so far as possible the personal element in making judgments.

The terms "character" and "temperament" immediately present themselves as soon as the term "personality" is mentioned. All of these concepts are interrelated and form a definite part of what is usually ascribed to any one of the concepts. However, certain distinctions that are conventionally drawn may be practically utilized. The distinctions set forth here are not the only ones possible, but only those that seem to me to be pertinent to our discussion.

"PERSONALITY," "CHARACTER," AND "TEMPERAMENT" DEFINED

Let us first consider the term "personality." It is derived from the Latin word *persona*, meaning mask, and its significance can be found in the clay masks worn by actors when portraying a particular part or in attempting to imitate a particular person. This historical notion implies the general appearance of the individual as the major attribute of personality. While general appearance is without question one of the aspects, the ideas of the Romans may again be consulted for further light on our present theories. Not only must the appearance of the actor be suitable for portraying a part but the acting must also be appropriate. This leaves personality somewhat less fixed and less rigid. It implies the individual in action and, hence, changing. We can therefore define personality as the picture or impression that any observer obtains of an individual at any given moment. You may ask—Does the individual ever present the same picture at any two successive moments? In general, no; but there are certain major patterns of reaction or portrayals that are fairly uniform over a long period of time. The complete understanding of any individual's personality requires intimate observations of reactions in a wide variety of situations over a fairly long period of time. For different observers any individual will present many so-called different personalities which signifies a changing or fleeting personality. Today, one may show quickness of decision; tomorrow, slowness and indecision; and on the next day, even unwillingness to consider a problem. The factors responsible for such changes can only be guessed in many instances. Here is a man who has been a valuable asset to an organization. His work becomes inaccurate; he quarrels with his inferiors and superiors; and he produces a deleterious effect on his colleagues. Is this man's personality change a long and steady growth, or is it merely a vacillation which up to that time had not made its appearance, but nevertheless was an integral part of his personality? This is one of the problems of measurement which will be considered later.

"Character" (often referred to as reputation) is an undeniable part of personality and may be defined as that aspect of personality, trait, or customary mode of reaction that differentiates one individual from another. When we say a man has a good character, or a bad character, all we imply is that in certain situations he reacts or does not react in the approved social custom. It does not imply some inherent mode of reaction that is immutable. A man may have a good character until he has been caught at embezzling. In regard to his reaction to stealing, we now say he has a bad character. That is, we are talking about a single trait of personality. He may still have a good character regarding his reactions to social conventions concerning sexual matters.

"Temperament" has a rather restricted meaning psychologically, although we are prone to confuse temperament with character and with the more general concept, personality. It is a definite part of the latter. According to Bridges, temperament may be defined as the total affective constitution or predisposition in regard to feeling and emotion. In other words, temperament may be regarded as the emotional response to a wide variety of situations. It may include such characteristic responses as apathy, overemotionality, or single emotional response as the chief component in numerous reactions.

You can see readily that the problem of measuring personality is inextricably tied up with the measurement of character and temperament. I am forced, as a result, to treat these as somewhat analogous terms in my subsequent discussion.

RELATION BETWEEN PERSONALITY AND PHYSIQUE

The ancients were familiar with the differences which occur in human behavior and speculated as to their causes. Their inadequate knowledge of physiology, chemistry, and neurology led, of course, to what, at the present time, may seem like humorous explanations. Some of their observations were acute and the bases thus established have persisted through history and are in vogue with certain modifications today. One of the speculations that would arise most naturally is whether there is any relation between personality and physique, including under the former certain reactions which may be called intelligence, and under the latter, stature and appearance. These speculations are rife at the present time and the experimental work of the psychologists has by no means lessened the

[1] This paper is the fourth of a series of addresses on "Business Fundamentals for Engineers," delivered at the Engineers Club of Baltimore. Other addresses in the series have appeared in the February, March, and April issues.

number of quacks who thrive on a gullible public, including both the educated and uneducated.

The ancient Greeks are the first on record to attempt to show the existence of such relationships. Statements about the matter will be found in the writings of Plato and Aristotle. The work was continued by Gall and Spurzheim, the phrenologists; Seeland, the anthropologist; Kraepelin and Kretschmer, psychiatrists; and was popularized in this country by the followers of Fowler, Blackford, and many others. Whatever the final judgment concerning the validity of the work of the persons mentioned, we cannot deny that they raised a number of questions that needed scientific investigation. It is useless to deny the fact that the physical appearance of some people is more agreeable than the physical appearance of others, and that appropriate physical appearance is a necessary adjunct in some business fields. The psychological work has not been directed toward determining the agreeableness or lack of agreeableness of physical appearance. It has dealt with the reliability of judgment of physical traits, and the relations of such physical traits as height, weight, hair color, eye color, shape of mouth, chin, head, and hands to such psychological traits as intelligence, perseverance, kindliness, conceit, courage, and truthfulness. The measurement of physical characteristics offers no unsurmountable problems, but when the psychological traits are scrutinized, difficulty is encountered in determining the possession of a specific trait either by one's self or by another. It is impossible to discuss all the experimental work in this field and only sufficient work will be mentioned to give you a brief acquaintance. In regard to the reliability of judgment of physical and mental traits by acquaintances or trained personnel men we can say that the following information is representative.

RELIABILITY OF JUDGMENT OF PHYSICAL AND MENTAL TRAITS

Hollingworth had 12 experienced sales managers rate 57 applicants for sales positions with the following results: Three applicants taken at random from the group were assigned by the judges rank positions ranging, for applicant 1, from position 6 to 56; applicant 2, from position 9 to 51, and applicant 3, from position 1 to position 57.

In a somewhat different experiment Magson had 149 students rated by approximately 25 judges who represented different occupational groups. Judgments were made on traits such as general ability, based on an interview; general ability, sense of humor, general cheerfulness, quickness of apprehension, and profoundness of apprehension, based on long acquaintance. The interviews were practically valueless, since there was slight agreement among the various estimates. The prolonged acquaintance did not produce much more promising results. Definition of the trait to be judged and some training of the judges in looking for the specific trait affords somewhat better results according to O'Rourke but his conclusions are subject to controversy.

Work that I have carried on indicates that even an individual's self-estimate of a variety of traits including honesty, cheerfulness, laziness, and awkwardness are above the average for desirable traits and below the average for undesirable traits.

Rating scales and judgments of character traits from an interview or personal acquaintance are, on the whole, unreliable.

Intelligence, which the layman assumes he is able to judge with some proficiency, is even less accurately estimated than character traits when the estimates are made on a basis of physical appearance. The feebleminded, especially the moron, may be rated high in intelligence and the normal individual cataloged as inferior. Mistakes in judging the intelligence of idiots and imbeciles are not likely to occur, since the physical signs are usually prominent. Anderson's experiment on rating general intelligence on the basis of general appearance is directly applicable to a business situation. Portrait photographs of 69 of the more important executives of a large department store were bound in a company year book. These portraits were then sorted out independently by 12 graduate students into 4 groups: (*a*) The seven most intelligent, (*b*) the seven least intelligent, (*c*) the fourteen most intelligent, excepting group *a*, and (*d*) the fourteen least intelligent, excepting group *b*.

The average of the scores of these twelve judges was correlated with scores made on a modification of the Army alpha intelligence test with a result of +0.27. The experiment which I have cited involves the use of photographs and you may argue that more accurate judgments could be obtained from seeing the individual in person. Actually, experiments using this procedure do not give any more significant results. Cleaton and Knight have demonstrated that the popularly approved physical signs of intelligence, judgment, frankness, friendliness, will power, leadership, originality, and impulsiveness, give practically no correlation when rated either by close friends or casual observers. I should like to discuss at greater length the relation between physical characteristics and intelligence. It has already been shown that general appearance is no index of intelligence, but many people seem to reason that a given part of the physical structure is a better index than the whole. Rating scales and subjective judgments can be said with fairness to be unreliable indexes of general personality and intelligence.

The low correlations which have been found between personality traits and physical characteristics may be due to the fact that the judgments have been made of the individuals in repose. In order to overcome this difficulty several attempts at constructing personality tests, which involve activity capable of objective measurement, have been made. While these so-called personality tests do not entirely avoid rating scales and ambiguities of interpretation, the methods of approach employed seem more likely to succeed than the varieties of approach which have been under discussion.

OBJECTIVE TESTS

The Downey will-temperament test is one of the earliest of this type. It purports to measure such traits as speed of decision, flexibility, motor impulsion, resistance to opposition, reaction to contradiction, finality of judgment, motor inhibition, interest in detail, coordination of impulses, and volitional perseveration.

I shall describe in some detail the test since the method of approach is quite similar to that involved in some of the other investigations that will be mentioned.

For measuring speed of decision a list of personality traits is presented and the individual is required to rate himself positively or negatively. A measure of speed of movement is obtained by having the individual write his name, or United States of America, at his accustomed rate. Flexibility or ability to change is measured by writing a phrase in a disguised hand and by copying a phrase written in an entirely different hand; motor impulsion, by having the individual perform an habitual motor reaction while carrying out simultaneously some mental reaction; finality of judgment, by the number of changes made in the original checking of the personality traits; motor inhibition, by performing an habitual writing task at a speed much slower than the accustomed speed; and interest in detail, by the preciseness with which the individual copies a sample of handwriting.

In all of these situations the individual is requested to make a response and the responses can be measured objectively. Mirror drawing has been employed for determining the ability

of subjects to change habitual reactions, but it has been designated as measuring a wide variety of character traits. Fear reactions to electrical shock, to pain, and to unexpected stimulation, such as snakes thrown upon the individual, have been obtained by various psychological methods. These methods include changes in respiration rate, pulse rate, and in skin resistance. Unfortunately, there is no quantitative change in the subject's reactions which is directly proportional to the strength of the stimulus. In addition, we cannot be sure either of the subject's past experience or of the nature of the reaction itself. I will mention still another objective test supposed to measure inhibition. A subject's hand is placed directly under a large weight that is visible. He is told that the weight will be released but will be stopped before striking his hand. The tendency is to withdraw his hand. An objective measure is finally obtained of the number of trials required for him to overcome this tendency toward reaction.

There are several major objections to tests of this type, although these objections do not invalidate the methods, provided enough information is secured by more thorough experimentation. In the first place, we have no way of knowing that the performances are accurate indexes of what they aim to measure; in the second place, a test situation differs from an actual life situation; and in the third place, it is somewhat fallacious to assume that a single performance or a specific detail of performance is indicative of performance in general or represents a general trait.

Lanier has demonstrated that among certain types of motor reactions there is a fair degree of correlation, whereas these motor reactions show little relation to speed of response when complex thought processes are involved. The work at present points toward certain factors that control speed of response in closely knit groups which are independent of one another. Speed of finger movement correlates well with speed of wrist movement and speed of arm movement, but how these correlate with speed of foot movement needs to be definitely ascertained. In some of my recent work, to determine whether there is a unit trait of volitional perseveration, four widely divergent tasks were utilized. These tasks consisted of perseveration in a situation involving speed of reaction, slowness of reaction, fine muscular coordination, and reasoning. Although the data have not been correlated, superficial examination leads me to believe that there is some correlation between perseveration in fine muscular coordination and reasoning and little correlation among the others.

To put the problem with which we have been concerned in every-day terminology, we would have to say that a man who would not steal ten cents, would not steal one hundred dollars. Also, that a man who would not steal one hundred dollars when he is likely to be caught, would not steal one hundred dollars when he is unlikely to be caught. At the present time the predictive value of the tests outlined can only be worthwhile provided they are used by experts in conjunction with other information obtainable about the person examined.

TESTS FOR INTROVERSION AND EXTROVERSION

There is still a third group of tests which are mainly of the rating variety. These tests have been developed for a specific purpose and consequently may be discussed by themselves. They have been designed to discover emotional instability or measure certain general tendencies with respect to egocentricity or its opposite, frequently referred to as introversion and extroversion. Samples of this type of test are to be found in Woodworth's psycho-neurotic inventory, Allport's ascendance-submission reaction test, Thurstone's neurotic inventory, and Bernreuter's personality inventory. In practically all such tests, the individual is required to decide whether he possesses a specific trait, whether he performs certain acts, and whether he reacts emotionally to specific situations. The contents of any test include a number of items that are presumably characteristic of the neurotic, of the so-called introvert, of the so-called extrovert, and of the normal individual. The following list will enable you to form some idea of the personality features involved in extroversion and introversion.

Introvert signs	*Extrovert signs*
Blushes easily	Rarely blushes
Reticent of speech	Outspoken
Keeps possessions to himself	Shares possessions
Makes friends with difficulty	Makes friends easily
Argues	Yes man
Rewrites, adds postscripts to letters	
Worries	Free from worry
Indecisive	
Rebels at orders	Takes orders
Day dreams	Thoughts expressed in activity

In detecting incipient neurotic conditions emphasis is placed on still different characteristics. For example, questions similar to the following are asked:

Do you usually feel well and strong?
Do you have nightmares?
Do you know of anybody trying to harm you?
Do you worry about little things?
Do you ever have queer feelings as if you were not your own self?

Questions and tests of this variety would be useful in securing information about people, provided the questions were not ambiguous; provided the individual actually remembered the facts necessary for the answers; and provided, the individual was not anxious to conceal the condition which the tests are purported to measure.

Of what use are neurotic inventories, introversion-extroversion, and submission-ascendance tests in business? Theoretically, they could be invaluable, since a different type is desirable for a salesman, for a policeman, and for an executive. It is obvious also that a different type of personality is required for a repetitive job from that for a job requiring a shift from one type of work to another. In all these situations the emotional attitude or response of the worker shapes in a large measure his performance and satisfaction. If tests of emotional stability only enable us to select persons who are stable without supplying another iota of information, the time spent on their construction will be justified. The unstable individual may be costly to an organization, because he is apt to be inefficient and a disturbing element for other employees.

TRADE AND APTITUDE TESTS

Personality tests are usually fashioned to throw light on major patterns of reactions and on specific traits of reaction which are developed through the individual's contacts with life. The tests already discussed are distinguished from two other major groups, trade tests and aptitude tests. Trade tests presumably measure what the individual has learned from taking part in a particular trade or occupation. I shall not discuss this group of tests more than to point out that there are available at the present time tests for quite a variety of occupations.

Aptitude tests, on the contrary, involve the detection of inherent ability for engaging in a particular occupation, when the individual has had little or no previous experience. For

example, can we determine what characteristics are essential in selecting a good monotype operator, a bricklayer, or a social worker? Here again I seem to be reverting to a certain extent to a discussion of personality. I must admit that personality will play an important part in determining fitness or aptitude for specific occupations. There are, however, other traits that seem to be of more significance than so-called personality; that is, speed of movement, length of fingers, accuracy of coordination, sense of rhythm, and speed of comprehension. Tests for measuring such performances are numerous and batteries have been successfully assembled for a number of aptitudes. I might mention tests of mechanical ability, musical ability, aesthetic appreciation, selling ability, engineering ability, medical ability, and clerical ability. Standardization of these tests is possible since we can select a variety of performances and check the test performances against actual findings in the field. We may decide that a number of factors are involved in successfully operating a monotype machine, or in selling. We can then administer the tests to a large number of actual monotype operators, or salesmen, and determine which items of the test correlate with proficiency.

VOCATIONAL-INTEREST TESTS

The recognition of these problems has led to the growth of another group of measuring devices which have been called vocational-interest tests. Psychologists are now busily engaged in their development. It is one thing to know what a man is capable of doing but quite another to know that he will do that of which he is capable. Working on the theory that an individual will likely do that in which he is interested, research workers have endeavored to find means of measuring such interests. It must be recognized that the term interest covers a multitude of diverse factors. One may be interested now in reading, at another moment in physical exercise, later in studying mathematics, and still later in perusing some painting or drawing. It cannot be said that interest is analogous to liking, because a man may be interested in a murder but does not like murder. He may be interested in how oysters propagate and move without liking to eat oysters. The greater our knowledge of a man's interest, the more likely can some prediction be made concerning his future activities. Interest tests have not been developed for the purpose of ascertaining all the various factors that have interested the individual but have been concentrated upon measuring some more general tendency related to specific vocations. The workers in this field recognized in the beginning that environmental factors influence interest. They also understand that interests change in accordance with environmental influences. The picture is further clouded by the fact that interest influences success and success in turn influences interest. Evidence on these points has been assembled and is worth our attention for a few minutes. Fryer, after a study of the data obtained by a number of people, concludes that:

> In general, it may be said that for a period of one year, whether the subjects are in colleges, high school, or elementary school, there can be expected, on the average, about 50 per cent permanence of specific vocational interest. In other words, there is about a 60 in 100 chance of predicting specific vocational interests a year hence from present ones. For longer periods, the permanence of the specific vocational interests is less and the changes of predicting vocational interests two or more years hence is much less than that of 50 in 100. . The basis of guessing future interests, of course, is far less than 50 chances in 100. It is the fraction of one over the number of occupations with which the subject has informational contact. These results indicate a considerable degree of permanence of specific occupational interest in the mental life of the individual.

As Fryer has suggested, knowledge of occupations changes interests. Youngsters are more familiar with the occupations of their fathers than with most others. This knowledge may react on the youngster's interest, since he is familiar with the disadvantages. In this country about 10 per cent of sons will be interested in the father's occupation. Since there is a definite distribution of occupations, and since the majority of people prefer occupations in which there are fewest opportunities, a wide spread results between interest in occupation and subsequent engagement in that occupation.

We know that certain occupations require definite intellectual ability and the tendency is for individuals to gravitate toward those occupations for which their mental equipment is adequate. This raises the question as to whether individuals' interests coincide with their capabilities. We find from experiments on educational interests that the relation between estimated educational interests and educational abilities by the individual is approximately 60 per cent correct. These general statements concerning interests need to be amplified further by a discussion of the measurements of interest. Miner, Moore, Strong, Thorndike, Terman, Freyd, Kitson, and Fryer may be listed among the investigators. Their efforts have followed somewhat the same lines as the work on measuring personality traits. Rating scales with their attendant difficulties were developed in numerous forms. In most cases the individual tested was required to decide his preference for one of two lines of activity. In some tests the questions were related to particular occupations; in others the questions were more generalized.

Moore, using an interest blank of somewhat the same nature, made a survey of the interests of Westinghouse engineers. He wished to differentiate the sales engineers from the design engineers. He selected a number of occupations and activities that require mechanical ability and a number that require social ability. He then had the engineers designate on a relative scale those items that they preferred. He found 78 per cent correct placements of the sales engineers and 82 per cent correct placements of the design engineers. If a correction is made for those cases incorrectly placed, his inventory gives a validity of 60 per cent. In a subsequent investigation he gave the inventory to a group of engineers in training and followed up the placement of the men. From one group of 58, 85 per cent correct placements could have been obtained by the results in the inventory and 68 per cent of another group of 121 would have been correctly placed. Later follow-ups on these men showed even more significant results.

Moore did not attempt the major problem of differentiating engineers from other occupational groups. Strong's work on this point, while open to serious criticisms, is interesting and may prove valuable. He found that engineers could be distinguished from the following occupational groups, artists, ministers, certified accountants, lawyers, personnel men, bankers, life insurance salesmen, and office workers in 64 cases out of 100 on a basis of his occupational interest test. Strong later attempted to develop a scoring key to be applied to the same test that would differentiate civil, electrical, mechanical, and mining engineers. His attempts in this direction were unfruitful.

I have presented a sketch of the various attempts to evaluate personality. While the details have been eliminated by necessity, the more generalized findings have been reported. Most of the work of the psychologists has been painstaking and careful, and I believe that their efforts have been conducive to a better understanding of the many problems that arise when man and the machine are brought together. Personality, in spite of its elusiveness, has been at least partially evaluated and may lend itself to more accurate determination in the future.

The DNIEPROSTROY TURBINES

A Description of Nine Units Manufactured in This Country for U.S.S.R.

By D. G. MOORHEAD and R. V. TERRY

NEWPORT NEWS SHIPBUILDING & DRY DOCK CO.

THE DNIEPROSTROY hydroelectric and navigation development formed a part of the first five-year plan of the Soviet government for the industrialization of the country. It is located at Kichkas in the southwestern part of Russia on the Dnieper River about 200 miles above the point where the river enters the Black Sea. Construction of the dam started in 1927, and the first power-generating unit was placed in operation in May, 1932. Design and construction of the dam and power house was planned and executed by the Soviet government under the supervision of Hugh L. Cooper & Co., Inc., consulting engineers.

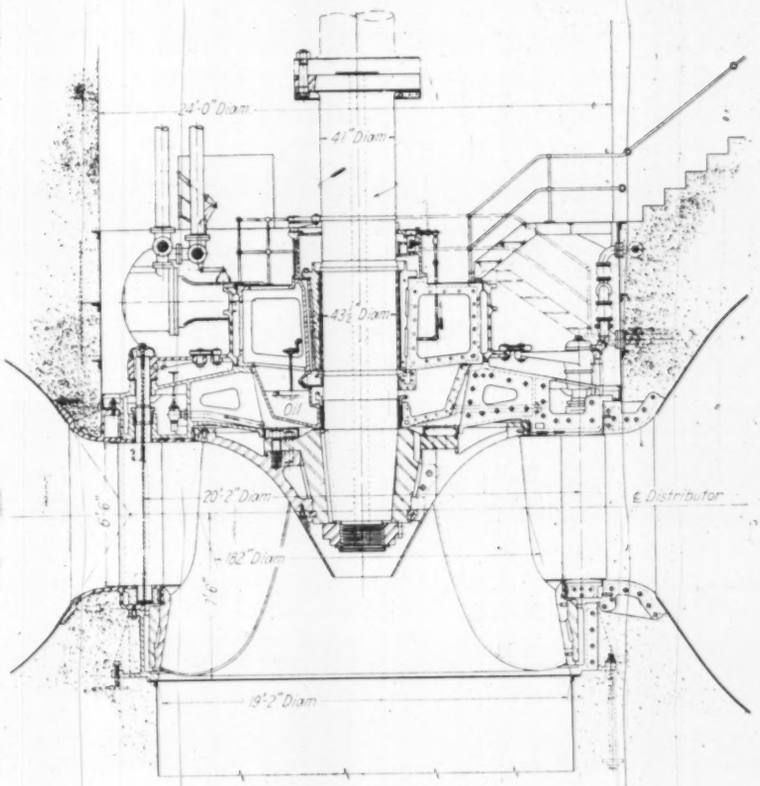


FIG. 1 SECTION THROUGH DNIEPROSTROY TURBINE

The size of the development[1] is indicated by the following dimensions of the structures: Length of dam, 5000 ft; height of dam, 140 ft; length of spillway section, 2005 ft; length of reservoir, 60 miles; drainage area, 170,000 sq miles; maximum recorded flood, 835,000 cfs; length of power house, 820 ft; maximum gross head, 123 ft; normal gross head, 116.5 ft; estimated ultimate annual production of power, 2,500,000,000 kwhr.

GENERATING UNITS

Five generators and other electrical equipment were furnished by the International General Electric Company. The main parts of four other generators were manufactured in Russia. The Newport News Shipbuilding and Dry Dock Company, of Newport News, Va., furnished the nine turbines which constitute the ultimate development. They are of the vertical single-runner type with spiral casings of steel plate.

Particulars of the nine power-generating units are as follows: Rated output per unit, 77,500 kva; rated capacity of turbines, at maximum efficiency and at 116.5-ft gross head, 84,000 hp; full gate capacity of turbines at 123-ft gross head, 100,000 hp; maximum water capacity per unit, 8500 cfs; speed, 88.2 rpm; unit spacing, 72.2 ft.

Design of the turbines was started in March, 1929. The ninth and last turbine was delivered at the manufacturer's piers for transportation in April, 1932. The contract involved the furnishing of turbines of the greatest unit power capacity as well as the greatest plant capacity undertaken until the Boulder Dam development was started.

The shafts were the largest and the runners and spiral casings the heaviest built up to that time. The design was intimately associated with problems of sectionalization for transportation from foundries to shops, as well as from ports on the Black Sea by barge and rail to the power plant. The heaviest individual pieces weighed from 40 to 50 tons. The weight of each complete turbine is about 1000 tons.

Shop work was carried out in the English system of measurements but drawings were supplied for field use in both the English and metric systems.

An enlarged sectional view through the turbine is shown in Fig. 1. A cross-section through the power house and intake is shown in Fig. 2.

SPIRAL CASINGS AND PENSTOCKS

The inlet diameter of the turbine casings is 25 ft, and the transverse width of each casing is about 68 ft. Each casing is constructed from about 76 major pieces of steel plate ranging in thickness from $1^1/_8$ to $^3/_4$ in. The sectional areas were proportioned on the basis of a uniform velocity throughout the length of the casing. The design was based on a maximum tensile stress in net sections of 10,000 lb per sq in. under the maximum static head of 113 ft. Riveted lap joints designed for inside calking were used. The rivets have button heads on the outside and countersunk oval heads on the inside. To facili-

Contributed by the Hydraulic Division for presentation at the Semi-Annual Meeting, Cincinnati, Ohio, June 19 to 21, 1935, of The American Society of Mechanical Engineers.

[1] A general description of the development can be found in the June 23, 1932, issue of *Engineering News-Record*.

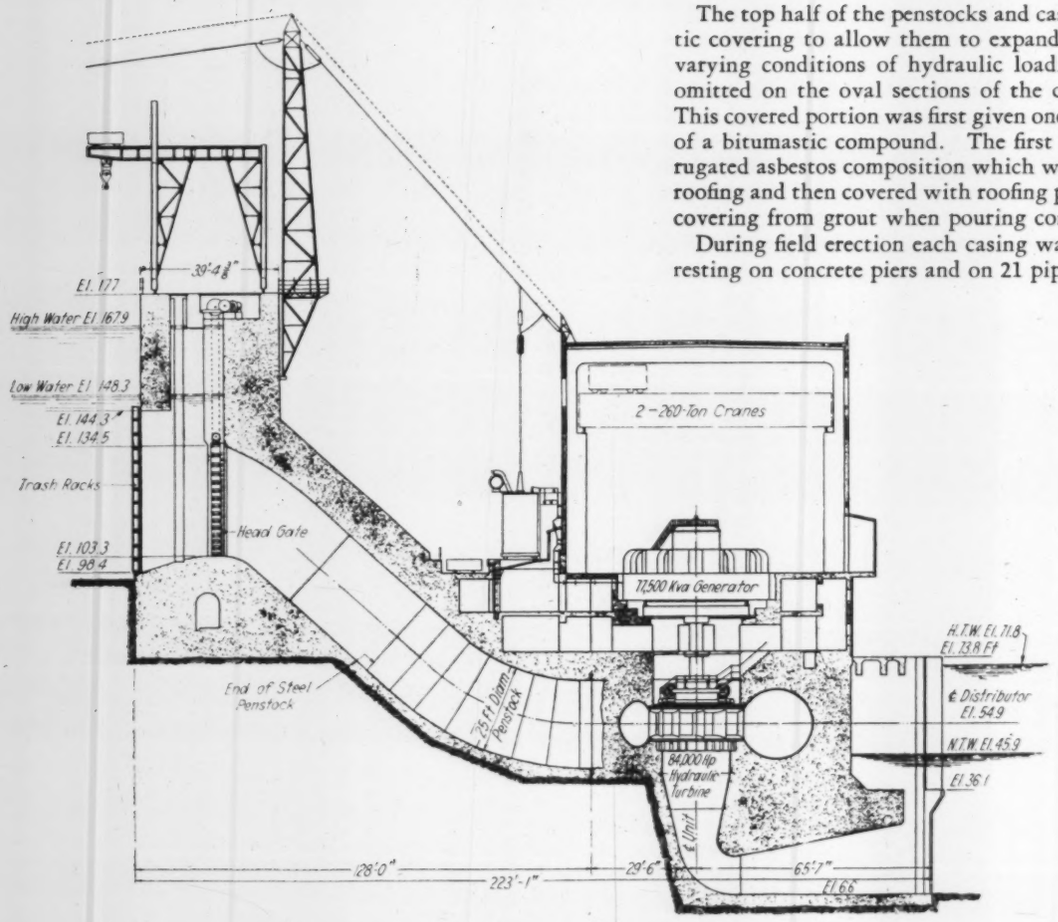


FIG. 2 SECTION THROUGH DNIEPROSTROY POWER HOUSE

tate construction a portion of the small end of the casing was made larger than necessary. A baffle plate welded in after field assembly gave the proper net cross-sectional area and the space between it and the body casing was filled with concrete.

Each plate was developed in the drawing room to one-eighth size for ordering material and for providing offsets to the shop for laying out and shearing to the necessary curved edges. After shearing and rolling to templets, each plate was cold pressed between dies on a hydraulic press to form smooth continuous curves with the adjacent plates in order to produce a good water passage. After shop fitting to the adjacent plates, the plates were assembled on the speed ring under shipway and gantry cranes and the rivet holes were reamed. Certain plates near the junction of the small and large ends of the casing were hot formed to templets taken from work. In assembling the casing it was found necessary to brace the speed ring with adjustable tie rods diametrically disposed to prevent distortion by the heavy plates.

About 75 ft of riveted-steel-plate penstock, 25 ft in diameter, including an elbow of about 45 deg, was furnished with each unit. The upper part of each penstock is of reinforced concrete. A diaphragm-type expansion joint was provided in each steel penstock at the expansion joint between the power house and intake structures.

Casings and penstocks were shipped completely knocked down. About 20,000 $1^1/_8$- and $1^1/_4$-in. rivets were used in each unit. Fig. 3 shows an assembly of one casing under a shipway crane at the manufacturer's shops.

The top half of the penstocks and casings were given an elastic covering to allow them to expand and contract under the varying conditions of hydraulic loading. The covering was omitted on the oval sections of the casing at the small end. This covered portion was first given one coat of red lead and one of a bitumastic compound. The first layer was of $^3/_4$-in. corrugated asbestos composition which was overlaid with asphalt roofing and then covered with roofing pitch to protect the main covering from grout when pouring concrete.

During field erection each casing was supported on 18 jacks resting on concrete piers and on 21 pipe shores resting on steel wedges. These auxiliary parts were left in place and concreted in with the casing. To prevent the casing from floating when pouring concrete, 20 Z-shaped holding-down straps were riveted to the bottom of each casing, concreted in, and allowed to set before the main lifts were poured. The interior of the casing was elaborately braced with timber shores to prevent deformation.

DRAFT TUBES

Each draft tube is of the elbow type with one central pier in the horizontal leg. The top diameter is 19 ft 2 in. Two discharge openings are each about 27 ft wide by 20 ft high. The tube is lined with steel plate to a point 17.75 ft below the centerline of the turbine distributor. It is greatly flattened and widened as it approaches the elbow where its depth is only about half the top diameter. The width at this point is about three times the top diameter. Sectional areas are proportioned so that no attempt is made to reduce the velocity in the short elbow section.

No manhole is provided in the draft tube as sufficient room is not available above normal tail-water level. Openings between the wicket gates and runner vanes are ample for access to the under side of the runner. Tail-water level frequently rises as high as the center line of the casing. Because of this it is usually necessary to insert the draft-tube stop logs and pump out the draft tube and casing for inspection purposes. The casing is drained into the draft tube through a 20-in. steel drain pipe with gate valve.

The draft-tube liner is constructed of $^1/_2$-in. steel plate reinforced with angles and Z-bars.

FOUNDATION AND SPEED RINGS

A separate foundation ring of cast iron in halves was used instead of extending the speed ring down to the draft-tube liner. Each foundation ring was provided with twelve $2^1/_2$-in. leveling screws and the same number of foundation bolts for accurately holding the ring in place while erecting the speed ring and casing. This ring acts as a spacer between the draft-tube liner and speed ring and carries the weight of the runner and shaft when these parts are disconnected from the generator.

The speed ring is of cast steel and of customary construction. It is 27 ft in diameter across the vanes and is made in quarters to facilitate handling. It is partly triple and partly quadruple lap-riveted to the spiral casing plates. The speed ring is provided with twelve stay vanes, one-half the number of wicket gates, each with a cross-sectional area of 150 sq in. The tensile stress on the vanes opposite the large end of the casing is estimated to be 10,500 lb per sq in. under full head with 50 per cent pressure rise. The radial joints were grooved and gunned with red-lead putty to make them water-tight. The surface for receiving the crown plate was also grooved and provided with a $^3/_8$-in. round rubber sealing cord.

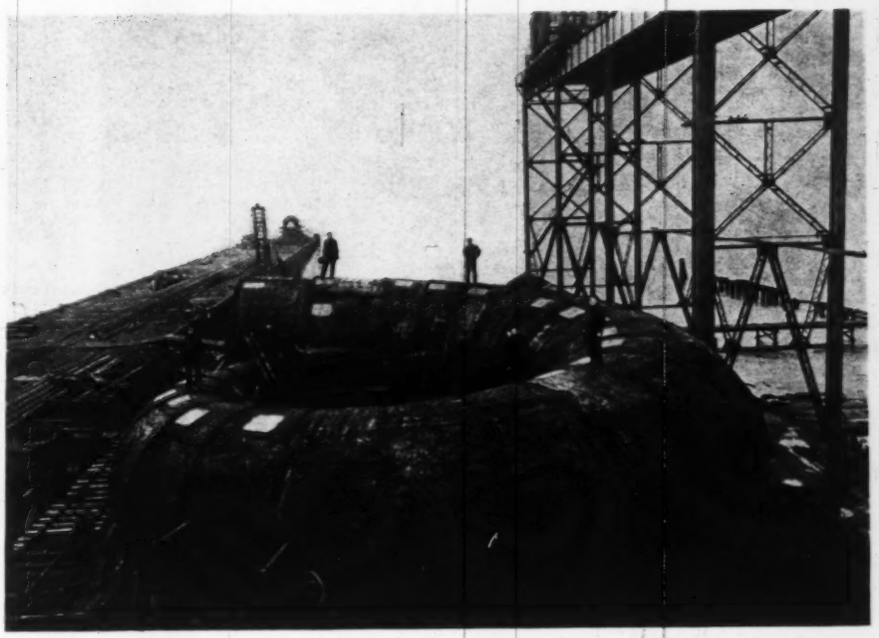


FIG. 3 ASSEMBLY OF A TURBINE CASING FOR DNIEPROSTROY

CROWN AND CURB PLATES

The crown and curb plates are each made in halves of cast iron of high tensile strength. Their surfaces opposite the wicket gates and periphery of the runner are provided with cast-steel wearing plates. A separate cast-iron upper extension of the crown plate, which is constructed in halves, carries the main-shaft bearing and serves as a guide for the gate-operating ring.

The crown plate is provided with two bronze-bushed bearings for each wicket gate stem, the lower bearing incorporating a stuffing box to reduce leakage. Leakage from these stuffing boxes, together with leakage from the main-shaft stuffing box, accumulates in the outer part of the crown plate from which space it is drained by two 3-in. connections through the crown plate to the space above the runner where there is always a vacuum except during periods when the tail water is extremely high.

A large ejector operated continuously by penstock pressure is also installed as an auxiliary means of draining the leakage water. The ejector suction is provided with a check valve to prevent water backing into the turbine pit in case the pressure supply should become clogged.

The crown plate forms two seals at the crown of the runner, with a baffle plate between, arranged to reduce to a minimum the hydraulic thrust on top of the runner. The runner crown leakage passes inward and downward to the center of the draft tube through cored holes in the runner hub and runner cap.

The one gate-stem bearing for each gate in the curb plate is greased through a central hole and pipe extending through the gate from the top end of the stem.

PIT LINERS

Each pit liner is 24 ft in diameter inside and about 8 ft high. The liners are constructed entirely of steel plate and structural shapes with three vertical double-riveted butt joints and are provided with two pockets arranged as a foundation for the servo motors. The servo-motor reactions are carried into the concrete, directly in compression, and in tension through eight $1^1/_2$-in. foundation bolts extending well back into the concrete. The bolts were designed for prestretching from the inside of the liner after concreting and before installing the servo motors. This arrangement has proved rigid and satisfactory in operation.

RUNNERS

The large cast-steel runners presented the greatest problem in sectionalization for shipment and in securing adequate sections to carry the large centrifugal forces and torque involved. The design adopted consists of six major parts: three vane sections each with five vanes, a central hub section, and two main shrink bands. An additional wearing band, constructed from steel bars with welded joints, is shrunk on opposite the curb plate. The vane-section castings weighed about 80,000 lb each. The total finished weight of each runner is about 140 tons.

The central hub section is 9 ft in diameter and is arranged for a taper fit on the lower end of the main shaft. It is fastened to the vane sections with eighteen 5-in. studs but the torque is carried by eighteen 5-in. dowels. Studs were shop driven, using a pulley, rope, and crane.

In addition to being bolted to the hub section, the vane sections are held together at the crown by means of a solid, angle-shaped, cast-steel shrink band at the periphery. This ring is also bolted to the vane sections.

The principal centrifugal forces occur at the lower band where they are carried by a solid cast-steel shrink band 19 ft $10^1/_2$ in. in diameter, weighing about 35,000 lb. The shrink fits were tapered $^1/_4$ in. per ft on diameter so that the band could be tried on in the shop to check accurately the shrinkage allowance. This band is not bolted or doweled to the vane section of the runner. The estimated stresses in the shrink band and inner sectional band are as given in Table 1.

TABLE 1

	Tension in shrink band, lb per sq in.	Compression in inner band, lb per sq in.
Static	10300	9350
Normal speed	11750	7950
Runaway speed	14550	5150

The runner was temporarily checked for static balance in the shop and after assembly in the field was finally balanced in an upright position. The equipment for balancing the runner in-

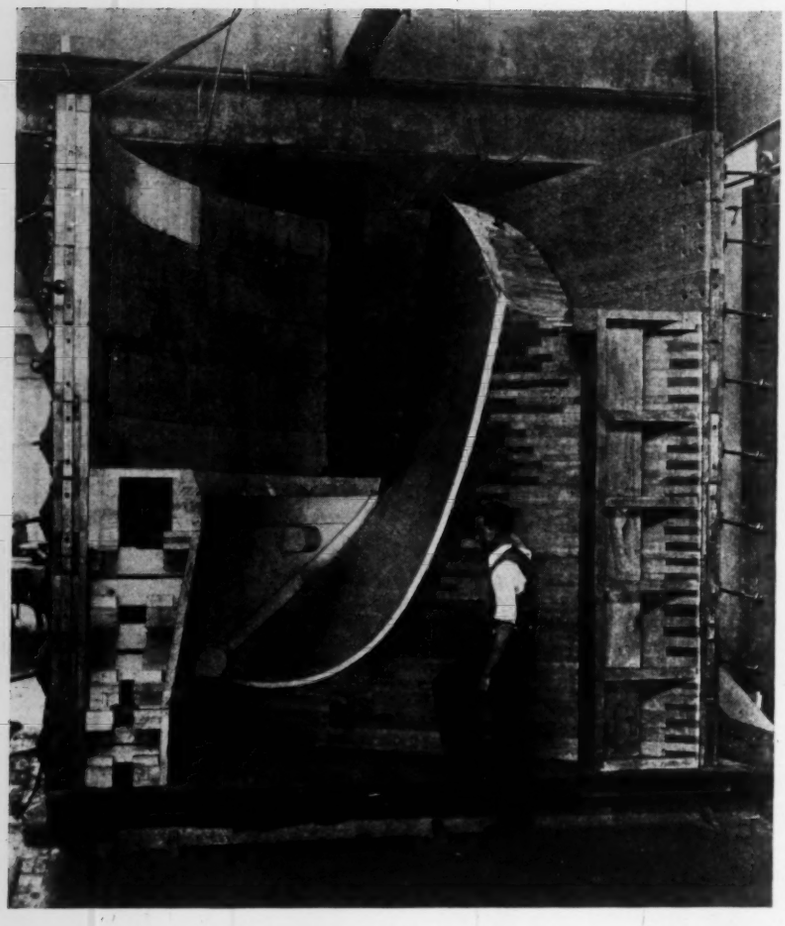


FIG. 4 CORE BOX FOR RUNNER-VANE SECTIONS

cluded a center casting at the hub bore with a hardened-steel center and a 5-in.-diameter spherical point located slightly above the center of gravity of the runner. The center rested on a hardened steel plate supported by blocking from the floor. This method of checking the balance proved to be sensitive to about one pound at the band diameter. Balance was obtained by eccentrically turning certain portions of the vane sections of the runner. The maximum amount of metal to be removed for balance was about 2000 lb, or 0.7 per cent of the runner weight. Field balance, after final assembly and after removing temporary bolting lugs, was accomplished by chipping.

Static radial clearances of $^1/_8$ in. at the hub periphery and $^5/_{32}$ in. at the band periphery were provided. These are reduced slightly with the runner rotating at normal speed.

Fig. 4 shows the corebox for the runner-vane sections. This box is about 12 ft high and contains more than 10,000 fbm of lumber. It was substantially built as 162 cores had to be made from it. The runner lines were developed full size on zinc sheets from the model lines.

Fig. 5 is a shop view of a runner partly assembled. The temporary bolting lugs may be seen at the joints.

MAIN BEARING

The one main turbine bearing per unit is of the babbitted type, $43^1/_2$ in. bore by 54 in. high. Oil is normally supplied by a gear pump, belt driven from the main shaft. A standby motor-driven pump is available for use when starting up the unit and it is arranged to start up automatically by float switch in case the belt-driven pump should fail. The oil sump occupies a sector of the drain pan under the main-bearing housing. The pumps discharge into a reservoir and float chamber in the bearing cover. The oil then flows by gravity into an annular space between the shaft and a lip on the bearing shell, and then through the bearing clearance to the bottom of the bearing where it is collected and drained to the sump. Either pump supplies more oil than is required and the surplus returns to the sump through cored openings in the bearing housing. The entire lubricating system is located in and around the bearing housing.

The bearing was originally provided with a total clearance of 0.025 in. which proved to be too much, allowing the shaft to swing excessively at certain gate openings. The clearance was later reduced to 0.016 in. In the summer the bearing temperature runs about 126 F. No artificial cooling is employed except that the oil sump is partially in contact with water above the runner.

The main-shaft stuffing box below the bearing is packed with four rings of $1^1/_4$-in. square asbestos packing impregnated with graphite and oil. Some trouble was experienced with rotating packing, particularly before the bearing clearance was reduced. The customary lantern ring was removed and a similar but heavier ring placed at the bottom of the packing box. Water is supplied to this ring through two one-inch connections. Water is also supplied at two points at the top between the gland and shaft. A grease connection was provided but is not used, as grease increased the tendency of the packing to rotate.

MAIN SHAFTS

The turbine shafts have a nominal diameter of 41 in. with an 8-in. bore. Flanged couplings for connection to the generator

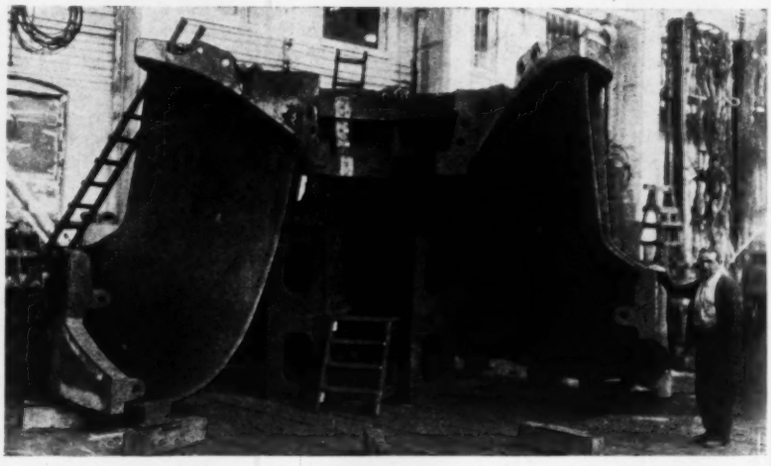


FIG. 5 PARTIAL SHOP ASSEMBLY OF RUNNER

shafts are 70 in. in diameter. It was considered better to use large shafts of ordinary forged steel with low stresses and greater rigidity than smaller shafts of higher tensile strength.

A forged-steel sleeve is shrunk on each shaft opposite its main bearing. This is not usually considered necessary with a babbitted bearing but in this case the investment in the shaft was rather large and the sleeve was provided for renewal in case the journal became pitted.

A hard-bronze sleeve was shrunk on and pinned to the shaft opposite the stuffing box. The asbestos packing has not caused the sleeves to wear appreciably.

Turbine shafts for five units, the number of generators built in the United States, were coupled to the generator shafts in the shop and checked in a lathe for alignment. This assembly was 57½ ft long and weighed about 125 tons.

Each shaft is secured to the runner hub by a 24-in. nut, 40 in. outside diameter, as well as by the customary split keeper ring. The use of a nut was convenient in this case because of the separate hub which was assembled on the shaft before bolting to the runner-vane sections. Ordinarily, the runner vanes interfere with the effective use of a wrench.

Two keys, 4½ by 6½ by 50½ in., 180 deg apart, were also used in connecting the hub to the taper fit on the shaft. The hub and shaft assembly was made in the shop, the hub being slightly warmed before placing it in position.

FIG. 6 DNIEPROSTROY POWER HOUSE AND DAM DURING ERECTION OF FIRST FOUR TURBINES

FIG. 7 INTERIOR OF DNIEPROSTROY POWER HOUSE

WICKET GATES AND MECHANISM

The wicket gates and operating mechanism are, in general, of customary construction, operated by two servo motors with oil at 200 lb pressure. Each turbine has 24 cast-steel gates with integral stems, 78 in. high between distributor plates. A total shop clearance of 0.030 in. was provided at the ends of the gates. As expected, this clearance reduced to about half the shop clearance when the complete units were erected and ready for operation. The superimposed weight caused this to occur.

Each gate link is provided with a cast-iron safety stud in tension when closing the gates. Alternate links, connecting gates opposite speed-ring vanes, are similarly provided with safety studs in tension when opening the gates, while those in between are provided with much stronger steel bolts. This arrangement prevents damage to the adjacent link when one stud breaks.

The operating rings are of steel cast in one piece. The servo motors are of the truncated-piston type, the pistons being provided with tubular extensions through the stuffing boxes. One cylinder is provided with a yoke extension which cooperates with a nut on the connecting rod and a removable horseshoe collar to lock the gates in the closed position. The combined displacement of the cylinders is 107.8 gal giving a capacity of about 415,000 ft-lb at 200 lb pressure. The maximum differential piston pressure occurs at about five-tenths gate and was found to be about 140 lb at 118.5-ft head when opening the gates. The gates are balanced near the speed-no-load position.

The gate mechanism is provided with individual grease fittings.

GOVERNOR EQUIPMENT

The governors are of the oil-pressure, relay-valve, actuator type, with 7-in. pipe connections. Inter-connected unit-pressure systems were adopted, each consisting of two 300-gpm double-helical-gear pumps, welded-steel pressure tank, and riveted-steel sump tank. One pump runs continuously, unloading to the sump tank when the pressure is above 180 lb. The other pump is used as a standby and is arranged to start up only in case the service pump should fail and the system pressure drop below about 170 lb. Each pump is directly connected to a 60-hp, 2300-volt, 50-cycle, 720-rpm motor supplied from the auxiliary generator on the main-generator shaft.

The actuators and pumps were supplied by the Woodward

Governor Company. The actuator fly-balls are motor driven by connection through transformers to the main-generator leads. The governor relay valves are set for a full closing stroke in about 4 sec. The speed rise at different loadings obtained on test by tripping the main circuit breakers was as given in Table 2.

TABLE 2

Load dropped, hp....	80000	60000	40000	20000	8000
Speed rise, per cent...	13.9	9.1	5.5	2.8	1.1

The low values of speed rise obtained are principally due to the large value of *WR*-square. The total *WR*-square of the entire rotor is about 178,000,000 ft²-lb.

FIELD ERECTION

The turbines were erected and placed in operation under the direction of four erecting supervisors from the manufacturer's shops. These men served in an advisory capacity and approved each stage of the work as it was finished. The erection was also under the inspection of the consulting engineering firm of Hugh L. Cooper & Co., Inc. The work was carried on with Soviet labor under the direction of Soviet engineers and supervisors. Erection of turbines was started in 1929 and completed in 1932. This required almost continuous work, 24 hours per day, without interruption for rest days or holidays. The erection was interrupted only during the record flood of 835,000 cfs in 1931.

Fig. 6 is a view of the power house and dam during erection of the first four turbines. Fig. 7 shows an interior view of the power house after completion.

MODEL AND FIELD TESTS

A 40-in. discharge diameter runner model with a conical draft tube was tested at Holyoke in 1926, sometime before the contract was awarded. This model gave an efficiency of about 93.0 per cent at the peripheral coefficient corresponding to normal head in the field.

Before construction was started a 17-in. discharge diameter runner model was tested in the manufacturer's laboratory with a model of the elbow draft tube. This model gave a maximum efficiency of about 87.9 per cent under a net head of about 9.0 ft.

Complete field-test results are not available. Two units have been tested, the water being measured by the Gibson method, supplemented by the current-meter method. Available preliminary results on one unit tested by the Gibson method indicate an efficiency of about 91.5 per cent, based on net head. The tests were made over two years after the turbines had been placed in operation, because the normal head could not be obtained earlier, due to the continuation of construction work. Fig. 8 shows a group of Soviet engineers who participated in the field tests.

OPERATION

The admission of air through two 3-in. connections on the crown plate proved beneficial in increasing the efficiency below about five-tenths gate. The discharge and gate opening required to operate the unit at speed no load was found to be decreased about 15 per cent by the admission of air. These air valves are open at all gate positions. Above six-tenths gate the vacuum under the crown plate decreases so that the quantity of air admitted is automatically reduced. Without the admission of air an extremely bumpy operating condition occurred at about 60 per cent gate, the exact gate opening varying somewhat with the head but apparently occurring always at about the same discharge. Carefully made laboratory tests indicate the effect of the air on the efficiency at this load to be about 0.5 to 0.75 per cent. Differences of this order are difficult to measure accurately in field tests. The maximum efficiency occurs at about 75 per cent gate opening and at an output of about 85,000 hp which is close to the designed rated load.

The existence of a tendency toward bumpy operation at certain gate openings below the point of maximum efficiency probably occurs in all fixed-vane turbines having either Francis or propeller-type runners. The condition seems to originate with unstable flow at gate openings where the water must of necessity whirl with the rotation of the runner. It seems to increase with unit dimensions possibly because the relative masses of structures are less with larger units. The admission of air to correct the condition is not new. Laboratory observations through glass windows in the draft tube show a wobbling vortex or void space at the center, rotating with the runner, with its speed relative to the runner varying with the gate opening and peripheral coefficient.

The turbines operated for a period at small gate openings and at reduced heads which produced a slight amount of pitting on the hub of the runners near the discharge edge of the vanes.

CONCLUSION

At present all nine turbines are installed. Six units have been placed in operation. The other three units will be started as the generators are completed in Russia and as the load demand builds up. Four units are now operated to develop about 200,000 kw for two systems. The power is used in steel furnaces and for smelting aluminum silicate as well as for other metallurgical work and for general industrial applications. The load is building up rapidly and it is expected that the regulated river flow will be utilized in the near future.

FIG. 8 GROUP OF SOVIET ENGINEERS WHO PARTICIPATED IN THE FIELD TESTS

The PIVOTED-MOTOR DRIVE

Its Theory and Design, and a Graphic Method of Solution

By ROBERT R. TATNALL

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THE most recent solution of the problem of the short-center drive is furnished by the pivoted-motor base in combination with a flat leather belt. In this device the motor is rigidly bolted to a pair of cast-iron or steel arms, which thus become essentially a part of the motor frame. Each arm carries a bearing, and through these a pivot shaft passes. The pivot is horizontally mounted in a cast-iron or steel base, and adjustments are provided for lining up the belt laterally and for taking up belt stretch. The motor as a whole is free to swing around the pivot, its weight being supported partly by the pivot and partly by the belt. This arrangement makes it possible to utilize the weight of the motor as a means of applying tension to the belt. An adjustment in the arms allows the motor to be moved toward or away from the pivot, thus regulating the lever arm of the motor weight and giving a wide choice of belt tensions.

I—THEORY OF THE PIVOTED-MOTOR DRIVE

By a simple application of fundamental dynamics, the tensions in the two belt strands of a pivoted-motor drive may be obtained when the motor weight, the belt speed, and the geometry of the layout are known.

Conversely, it is not difficult to calculate for a given drive how far behind the motor shaft the pivot must be placed, in order that the ratio of the tensions shall have a predetermined value.

The rotor and stator of the motor, including the two base-arms, constitute a dynamical system which is in rotational equilibrium about any horizontal axis. A mathematical statement that such equilibrium exists is to be obtained by equating to zero the sum of the moments about such axis, of all the external forces acting on the system.

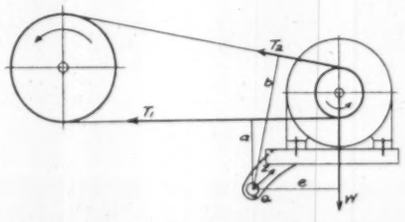

FIG. 1 EXTERNAL FORCES ON A BELTED PIVOTED MOTOR

Aside from wind resistance, there are four external forces acting on the motor system of Fig. 1. These are the force of gravity W, the tight- and slack-side belt tensions T_1 and T_2, and the force Z exerted by the pivot. The magnitude and direction of Z are unknown. W acts through the center of gravity of the system, which with small error may be assumed to lie in a vertical line through the center of the motor shaft.

CALCULATION OF THE BELT TENSIONS

To determine the unknown tensions T_1 and T_2 two relations between them are required. Taking moments about the pivot Q, in order to eliminate the unknown moment of Z, calling a, b, and e the lever arms about the pivot of T_1, T_2, and W, respectively, and regarding counter-clockwise moments as positive

$$aT_1 + bT_2 - eW = 0 \quad \ldots\ldots [1]$$

A second relation between the tensions is supplied by the fact that the transmitted load is proportional to the product of tension difference and belt speed, as expressed by

$$T_1 - T_2 = kP \quad \ldots\ldots [2]$$

in which

P = load transmitted in horsepower

$$k = \frac{33{,}000 \times 12}{Nd\pi} = \frac{126{,}000}{Nd} = \frac{33{,}000}{\text{belt speed in fpm}}$$

N = motor speed, rpm

d = diameter of motor pulley, in.

From Equations [1] and [2] the two belt tensions in terms of motor weight, load, speed and the three lever arms are obtained as follows:

$$T_1 = \frac{eW}{a+b} + \frac{bkP}{a+b} \quad \ldots\ldots [3]$$

$$T_2 = \frac{eW}{a+b} - \frac{akP}{a+b} \quad \ldots\ldots [4]$$

And from these

$$T_1 + T_2 = \frac{2eW + (b-a)kP}{a+b} \quad \ldots\ldots [5]$$

$$T_1/T_2 = \frac{eW + bkP}{eW - akP} \quad \ldots\ldots [6]$$

UPPER LIMIT OF LOAD

If we imagine the load to be increased until it reaches the value $P = eW/ak$, so that $eW - akP = 0$, then $T_2 = 0$ and T_1/T_2 = infinity. This is a theoretical limit to the load which cannot be exceeded without changing the assumed arrangement of the drive. Indeed, excessive slip will occur considerably below this point, and experiment has shown that the practical limit of load is reached at somewhere near 75 per cent of the theoretical maximum.

VARIATION OF TENSIONS WITH LOAD

Putting $P = 0$ in Equations [3] and [4], $T_1 = T_2 = eW/(a+b)$, which gives the stationary or idling tension in either belt strand. The second terms give the changes in tension (increase or decrease as the case may be), caused by applying a load of P horsepower. These terms involve also the belt speed, introduced by the factor k.

If a and b are positive, and the speed is constant, the equations show that any increase in the load will cause an increase in the tension of the tight strand and a decrease in that of the

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slack strand. In the usual fixed-center drive this always happens. In the pivoted-motor drive it usually happens, but not always, since there are cases in which a or b may be negative.

The form of Equations [2], [3], [4], and [5] shows that if a, b, and k remain constant, each of the quantities T_1, T_2, $T_1 + T_2$, and $T_1 - T_2$ is a linear function of the load P. If these quantities are plotted against the load, their graphs will therefore all be straight lines, having slopes equal in each case to the coefficient of P, so that

$$\begin{aligned} \text{Slope of } T_1 &= bk/(a+b) \\ \text{Slope of } T_2 &= -ak/(a+b) \\ \text{Slope of } T_1 + T_2 &= (b-a)k/(a+b) \\ \text{Slope of } T_1 - T_2 &= k \end{aligned}$$

These slopes involve only a, b, and k; k is always positive and is here assumed to be constant, which, while not usually strictly true, is nearly enough so for the present purpose; and a and b are positive when the pivot lies outside the angle between the belt strands. If, however, the pivot lies between the strands, either a or b is negative, accordingly as the lower strand is the tight or the slack one, because of the reversal of sign of the corresponding moment.

In general: When the pivot lies *outside* the belt strands, so that a and b are both positive

Slope of T_1 is + and T_1 increases with the load
Slope of T_2 is — and T_2 decreases with the load
Slope of $T_1 + T_2$ is + if $b > a$; i.e., tight strand next to pivot; and — if $b < a$; i.e., slack strand next to pivot.

When the pivot lies *inside* the belt angle

If b is — and $< a$, (T_1 above), slopes of T_1 and T_2 are both —.
If a is — and $< b$, (T_1 below), slopes of T_1 and T_2 are both +.

Thus in certain cases the sum of the tensions, and hence the bearing pressure, will decrease with increasing load.

The explanation of this apparent anomaly will appear from Fig. 2, in which the belt pulls T_1 and T_2 are drawn from their meeting point A, the tight strand in this case being above. Since T_1 is greater than T_2, their resultant R necessarily passes above the center of the motor pulley O. The moments of T_1 and T_2 about the pivot Q may be replaced by the moment of their resultant. This has the value RC, and it is equal and opposite to eW, the moment of motor weight, since there are no other moments. At zero load, T_1 and T_2 are equal, and their resultant R' passes through O. RC and $R'C'$ are each equal and opposite to the constant moment eW. Hence $RC = R'C'$, and since C is greater than C', R must be less than R', or the bearing pressure is less when the motor is loaded than when it is idling.

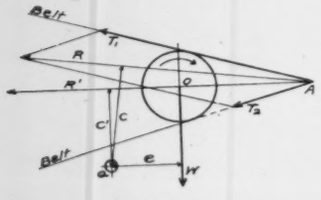

FIG. 2

EFFECT OF MUTUAL TORQUE BETWEEN ROTOR AND STATOR

The effect of reduced belt tension when the tight strand is on the far side from the pivot may also be considered from another point of view. The so-called "torque reaction" of the motor, as affecting pivoted-motor drives, has been much discussed, and not always with full understanding, so that it may be well to consider briefly its bearing on the problem.

Imagine a motor hung like a pendulum, with its shaft horizontal, and at first let it be not belted or otherwise loaded. Let the current be switched on so as to cause an initial acceleration, say in a clockwise sense. The counter-clockwise reaction of the stator will then exert at the point of suspension an instantaneous force toward the left. The system will therefore experience an external force applied at the point of suspension and directed toward the right, as a result of which the center of gravity of the motor will start to move toward the right. Hence there will be an initial counter-clockwise rotation of the motor as a whole, about the point of suspension. This is purely an effect of acceleration. As constant speed is approached, the deflection will drop to its initial or zero position.

In order to maintain a constant deflection it would be necessary to apply a constant external torque to the motor system, as, for example, by attaching fan blades to the motor shaft. At constant speed the system would then assume a constant deflection such as to bring about equilibrium between the torque due to air resistance and the gravitational moment due to weight.

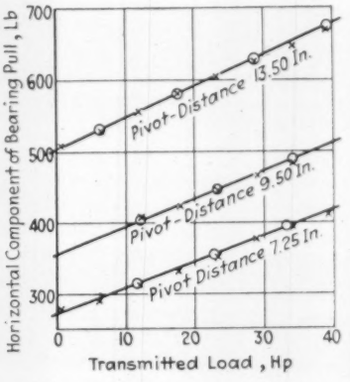

FIG. 3 EXPERIMENTAL CHECK ON THE CALCULATED TENSIONS

Passing now to the belted motor, the fan torque is replaced by the torque due to tension difference in the belt strands. As a result of motor torque, a twofold effect is produced: First, a tension difference due to the torque of the rotor, and second an overall tension, which may be attributed to the reaction of the stator, and which is an increase when the tight strand is next the pivot, and a decrease when it is on the far side.

But—and this is important—having, in the derivation of formulas for the tensions, introduced the motor torque in terms of horsepower and speed as by the factors P and k in Equations [3] and [4], the motor torque itself must then be forgot, and is now represented by the changes in tension which it has produced and which would not exist without it.

We are thus brought back to one of the fundamental concepts of dynamics, D'Alembert's principle, according to which a system is in equilibrium as to translation or rotation when the algebraic sum of all the externally applied forces or moments of force is zero. In other words, internal actions and reactions cannot affect the condition of equilibrium of the system as a whole. Such a condition of equilibrium is Equation [1] upon which the present formulas for computing belt tensions are founded.

If experimental confirmation is required of the validity of the belt tensions given by Equations [3] and [4], it is furnished by the curves of Fig. 3, obtained by means of the belt-testing machine. In these experiments a 25-hp motor was weighed and was then mounted on a pivoted base and used to drive the prony brake of the testing machine. In this machine the brake carriage is mounted on wheels traveling on rails and the belt pull on the pulley of the prony brake is transmitted by a steel cable to a platform scale. The loads transmitted were measured by the brake, while the tension scale gave the corresponding horizontal components of the total belt pull. The crosses on the curves indicate points thus obtained experimentally, while the circles are points computed by means of Equations [2], [3], and [4].

The tension ratio is

$$T_1/T_1 = \frac{eW + bkP}{eW - akP} \quad [6]$$

Evidently this is *not* a linear function of P. Calling $T_1/T_2 = y$ and $P = x$, Equation [6] takes the form

$$akxy + bkx - eWy + eW = 0 \quad [7]$$

which is the equation of a rectangular hyperbola whose asymptotes are the straight lines parallel to the axes

$$x = eW/ak \text{ and } y = -b/a$$

DESIGN OF PIVOTED-MOTOR DRIVE

The most direct approach to the problem of design appears to be through the tension ratio. Following this plan, the design of a particular drive to insure satisfactory performance under the given conditions will consist of two steps: First, a suitable value for the tension ratio must be decided upon. This will depend on the coefficient of friction between belt and pulley and on the contact angle on the smaller pulley. The second step is to calculate what position of the pivot with respect to the motor will produce the desired tension ratio.

CHOICE OF TENSION RATIO

The tension difference $T_1 - T_2$ being fixed by the given horsepower and belt speed, it follows that a low value of T_1/T_2 corresponds to a high total tension, accompanied by good frictional grip of the belt on the pulleys, but with the danger, when carried too far, of shortened belt life and burned-out bearings. On the other hand, as T_1/T_2 increases, T_2 decreases, and excessive slippage will eventually take place.

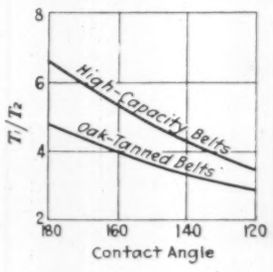

FIG. 4 TENSION-RATIO IN TERMS OF CONTACT ANGLE

To avoid both of these dangers, a suitable value of the tension ratio must be found which will give safe yet effective tensions. Such a choice depends on experience rather than theory, and is therefore a matter on which engineers may be expected to disagree. From the results of belt tests conducted over a period of years, together with favorable reports from a considerable number of pivoted-motor drives now in operation, the author has adopted for his own use the curves of Fig. 4, which apply to paper motor pulleys.

CALCULATION OF POSITION OF PIVOT

We have now to determine what horizontal distance between the pivot and the motor shaft will give the tension ratio desired. This will depend on the maximum load to be transmitted, the motor weight, belt speed, and general drive layout.

Designate by e this required pivot distance or overhang, and let

R = value of tension ratio to be used
W = weight of motor
N = motor speed at full load
P = maximum load to be transmitted. (A safe value for peak starting load will usually be obtained by multiplying the name-plate rating by 1.5 if the motor is compensator started, and by 2.5 if started across the line.)
D = diameter of driven pulley
d = diameter of motor pulley
$r = d/2$ = radius of motor pulley
h = height of motor shaft above pivot (obtained from dimension sheets of motors and pivoted-motor bases)
$k = 126{,}000/Nd$
m = angle of slant of tight strand of belt
n = angle of slant of slack strand of belt
x = horizontal distance motor shaft to driven shaft
y = height of driven shaft above motor shaft (negative when driven shaft is below motor shaft)
C = center distance between shafts

Equation [6] may be written in the form

$$R = T_1/T_2 = \frac{(eW/kP) + b}{(eW/kP) - a} \quad [6]$$

This gives

$$Ra + b = (R - 1)eW/kP \quad [8]$$

From Fig. 5 it appears that the lever arms of the belt pulls about the pivot are

$$\left.\begin{aligned} a &= h\cos m + e\sin m - r \\ b &= h\cos n + e\sin n + r \end{aligned}\right\} \quad [9]$$

in which r has a positive value when the tight strand is on the pivot side of the pulley, and negative when the slack strand is on the pivot side.

Substituting these values of a and b in Equation [8]

$$e(R-1)W/kP = R(h\cos m - r) + Re\sin m + h\cos n + e\sin n + r$$

Finally, solving this for e

$$e = \frac{h(R\cos m + \cos n) - (R-1)r}{(R-1)W/kP - R\sin m - \sin n} \quad [10]$$

Equation [10] is the working formula for e. In using it, the following conventions regarding signs must be adhered to:

Give r a positive value when T_1 is on the pivot side of the pulley and negative when T_2 is on the pivot side.

Give h a negative value if the pivot is higher than the motor shaft, as in wall or ceiling mountings.

The angles m and n are measured upward from a horizontal axis through the motor shaft drawn toward the pivot side. If either strand of the belt slopes downward from the motor pulley, the corresponding angle is therefore negative. In ceiling drives and in vertical drives, cases may occur in which some or all of the cosines and sines are negative.

COMPUTATION OF THE ANGLES m AND n

Find A = half the angle between belt strands

$$= \sin^{-1}\frac{D-d}{2C}$$

Accordingly, A will be negative when d is greater than D, i.e., in "speed-up" drives.

Also S = angle of slope of center line of shafts

$$= \tan^{-1} y/x = \sin^{-1} y/C.$$

S is negative when y is negative.

Then $m = S - A$ when T_1 is on pivot side of pulley
$= S + A$ when T_2 is on pivot side of pulley
$n = S + A$ when T_1 is on pivot side of pulley
$= S - A$ when T_2 is on pivot side of pulley

If preferred, we may lay out the drive to scale, and measure

m and n, instead of computing them. This plan will usually be quicker and less liable to error than the computation.

COMPUTATION OF THE TENSIONS

Having obtained the value of e, we may now compute the lever arms of the belt tensions a and b from Equations [9], or we may measure them on the scale drawing. The tensions are then readily found from Equations [3] and [4].

As a check, note that the values of the tensions here found should satisfy the relations

$$T_1 - T_2 = kP$$

and

$$T_1/T_2 = \text{the value of } R \text{ originally chosen.}$$

Illustration. In calculating the pivot distance for a pivoted-motor drive using a floor mounting, the following data were used: 25-hp compensator-started motor, 865 rpm, weight without base 730 lb; height of shaft above feet 11 in.; distance of pivot below top surface of arms of pivoted base is $4^9/_{16}$ in.; motor pulley 12 in. diameter, driven pulley 45 in. diameter;

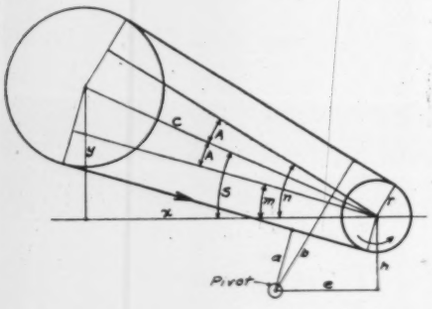

FIG. 5

layout as in Fig. 6 drawn to a scale of one inch to the foot; high-capacity belt to be used. The working data are (all linear dimensions in inches)

$P = 25 \times 1.5 = 37.5$
$N = 865$
$W = 730$
$D = 45$
$d = 12$
$r = +6$ (positive since T_1 is on pivot side of pulley)
$h = 11 + 4^9/_{16} = 15.6$
$C = 48.3$ (by measurement on sketch)

Then

$k = 126{,}000/(865 \times 12) = 12.0$
$kP = 450$
$W/kP = 1.62$
$A = \sin^{-1} 33/96.6 = 20$ deg
$R = 4.3$ by Fig. 4, since a high-capacity belt is to be used.

With a protractor, from Fig. 6, $m = -27$ deg and $n = 13$ deg.

Hence $\cos m = 0.890$ $\sin m = -0.450$
$\cos n = 0.973$ $\sin n = 0.225$

Substituting the above values in Equation [10]

$$e = \frac{15.6[4.3(0.890) + 0.973] - 3.3(6)}{3.3(1.62) - 4.3(-0.450) - 0.225} = \frac{55.0}{7.05} = 7.8.$$

Therefore the tension ratio will be 4.3 if the pivot is placed 7.8 in. back of the motor shaft.

The computed value of pivot distance and the calculation of the belt tensions may be checked as follows:

Since $e = 7.8$ in. and $h = 15.6$ in., the pivot in Fig. 6 may be located at the point shown. As Fig. 6 is drawn to scale in the original, from the diagram $a = 4.2$ in. and $b = 23.1$ in., so that $a + b = 27.3$ in. Hence, $eW = 7.8 \times 730 = 5700$, whence $eW/(a + b) = 209$, and $kP/(a + b) = 16.5$. So that finally, from Equations [3] and [4]

$T_1 = 209 + (16.5 \times 23.1) = 209 + 381 = 590$
$T_2 = 209 - (16.5 \times 4.2) = 209 - 69 = 140$

The tight-side tension is therefore 590 lb and the slack-side

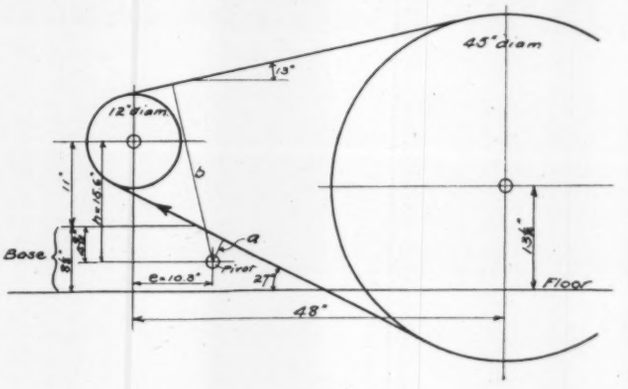

FIG. 6

tension 140 lb. If the load were taken off, the idling tension would be 209 lb in each strand of the belt.

As a check, $T_1 - T_2 = 450 = kP$

and $T_1/T_2 = 4.21$, or, practically, $4.3 = R$.

COMPARISON BETWEEN PIVOTED-MOTOR AND FIXED-CENTER DRIVE

In the short-center drive between fixed centers, the initial tension under which the belt is installed is almost never known, and is usually the result of guesswork. Even if the tension is initially correct, gradual belt stretch at constant load and sudden temporary stretches at peak loads, added to the stretch due to centrifugal tension in high-speed belts, will reduce the tension of the slack side. This often results in serious slippage. When slippage becomes evident, it is the usual practice to move the motor far enough back to stop the squeak, with additional tension added for good measure, involving the risk of ruined bearings and serious injury to the belt.

On the other hand, the pivoted-motor drive provides a means of knowing what the initial tension is, and of adjusting the running tension to the load to be carried. At constant load, the effect of belt stretch is taken care of by a corresponding change in center distance. The stretch of a new belt simply results in a gradual drop of the base arms below the level position, and this is easily corrected while the motor is running.

When the load varies, the change in slack-side tension in the pivoted-motor drive depends on the position of the pivot. We have seen that the slope of T_2 when plotted against load is $-a/(a + b)$. Consider a floor mounting, the tight strand being below. If the center line of the pivot is below the belt strands (a positive), the slope is negative, and T_2 decreases with load, finally becoming zero at the limiting load. If the pivot lies between the belt strands, a is negative, and T_2 increases with load. The pivot may, however, be exactly in line with the lower strand, and in this case a is zero, and T_2 remains constant at all loads.

An important advantage of the pivoted-motor over the fixed-center drive becomes evident in cases where sudden fluctuations in belt tension exist as a result of thick or stiff spots in the belt,

eccentricity in a pulley, or rapid changes in the load. In the pivoted-motor drive, tension peaks are smoothed off by a slight oscillation of the motor around the pivot.

GENERAL CONSIDERATIONS

It will readily be understood that not all drives are suitable for pivoted-motor installations. Naturally, some of these are drives which should not exist in any form. Inquiries regarding changes from fixed-center to pivoted-motor drives in order to cure excessive slip frequently reveal belt speeds so low as to demand dangerous belt tensions.

Then there are legitimate drives in which the motor is too light in weight to furnish the necessary tension, except by use of a pivot distance so great as to be mechanically unworkable. Indeed, it is little more than a fortunate accident that motor weights are so proportioned to speed and rated horsepower as to render the use of pivoted bases a good business proposition.

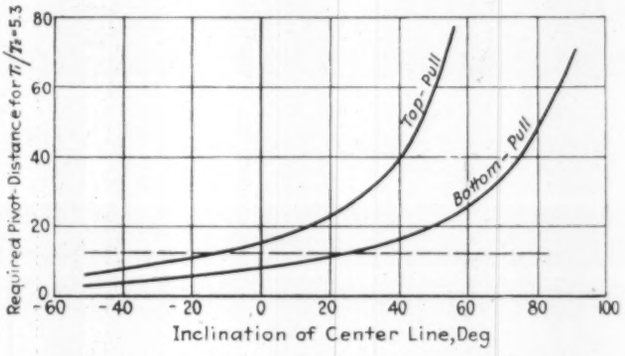

FIG. 7 PIVOT DISTANCE AS A FUNCTION OF SLOPE OF DRIVE
(10-hp motor, 1750 rpm, 6-in. motor pulley, 24-in. driven pulley, 48 in. center distance, $A = 10.8$ deg, $T_1/T_2 = 5.3$. Maximum pivot distance obtainable with this equipment, $12^1/_4$ in.)

A general reduction of 50 per cent in present motor weights would put out of commission most of the successful pivoted-motor drives now in use.

So-called "top-pull" drives require longer pivot distances than "bottom-pull" drives for the same tension-ratio. For this reason they are less favorable cases for pivoted-motor installations.

Ceiling drives, and all drives in which the pivot is above the motor shaft, are less favorable than similar drives from the floor.

The slope of the line of shaft centers is an important factor, as illustrated by the curves in Fig. 7, computed for the particular layout there described. Negative slopes mean that the motor shaft is higher than the driven shaft.

The discussion suggests certain points which the designer will do well to keep in mind. Some of these are:

Avoid low belt speed by proper specification of motor speed and pulley diameters.

Avoid extremely short center distances and high pulley ratios, since small contact angles require low tension ratios.

Use only high-capacity belts, since the belt tension demanded by the drive varies decidedly with the coefficient of friction.

Whenever possible, the lever arm of the tight strand with respect to the pivot should be kept small and less than the lever arm of the slack strand. To secure this condition in an existing drive may require that the rotation of the motor be reversed or the motor moved to the other side of the driven shaft. This applies to all types of mountings, whether on floor, wall, or ceiling.

An upward-sloping drive, if not successful, may often be made so by raising the motor on a pier, so as to decrease the lever arm a.

Evidently the pivoted-motor drive is not a cure for all ills, nor is it advisable in all cases, but it is an exceedingly useful device with the great advantage that the engineer can predict in advance of installation whether a given design will work or not. If it will not, he will be able, in most cases, to decide on a satisfactory remedy.

GRAPHIC METHOD OF DETERMINING PIVOT DISTANCE

The following graphic solution, suggested by Philip G. Rhoads,[1] has the advantage of visual presentation, and for some persons may prove simpler in practice.

Using the layout of Fig. 6, the problem, as before, is to find what pivot distance will give the desired tension ratio, $T_1/T_2 = 4.3$, at the peak load of 37.5 hp. The steps are as follows:

(1) Calculate the two tensions from the expressions

$$T_1 - T_2 = \frac{33{,}000 \times P}{\text{belt speed}} = kP, \text{ and } T_1/T_2 = R$$

Solve these for the tensions

$$T_2 = kP/(R-1), \quad T_1 = RT_2$$

In the present case, $P = 37.5$, $k = 12.0$, $R = 4.3$, so that $T_2 = 140$ and $T_1 = 590$, as previously found.

(2) Lay off to scale the tensions T_1 and T_2 from D, their point of intersection, as in Fig. 8. Construct the parallelogram of forces, and measure the resultant $G = 703$.

(3) Draw a line parallel to W at a distance from it proportional to G, and a line parallel to G at a distance proportional to W, using any convenient scale on the engineer's rule.

(4) Through B, the intersection of these lines, and A, the intersection of G and W, draw the line AB.

(5) Draw a horizontal line at the known distance h below the motor shaft. The intersection of this line with AB is the required position of the pivot Q. From measurement of Fig. 8, $e = 7.8$, as previously obtained by computation.

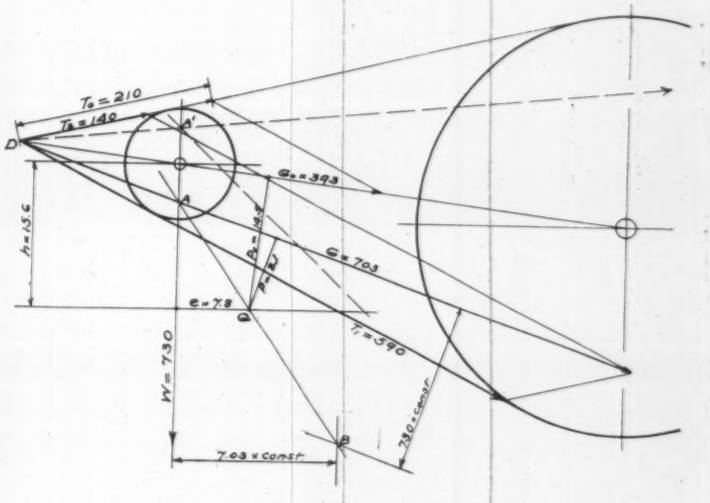

FIG. 8 GRAPHIC SOLUTION FOR PIVOT POSITION

(Continued on page 296)

[1] Chief Engineer, J. E. Rhoads & Sons, Wilmington, Del. Jun. A.S.M.E.

SIDE OIL FLOW *in a* 120-DEGREE BEARING

By GEORGE B. KARELITZ

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EXPERIMENTAL confirmation of the hydrodynamic theory of lubrication has occupied the attention of a number of workers in this field. The usual procedure has been to measure pressures existing in the fluid film and the location of the journal in the bearing and to compare these with the values computed on the basis of the theory for the clearance load, speed, and oil viscosity.

The recently published paper of S. J. Needs,[1] where a detailed analysis of a 120-degree bearing is given, presents an opportunity to compare theory and experiment from another viewpoint. It happened that the author measured some time ago the amounts of oil leaking out of a 120-degree bearing for various conditions of load and speed. Now, inasmuch as a formula and coefficients for the side leakage from such a bearing are given in Mr. Needs's paper, a comparison of the theoretical and experimental values of oil leakage will be of interest. The tests were run with the assistance of S. E. Amos at the Research Laboratories of the Westinghouse Electric and Manufacturing Company.

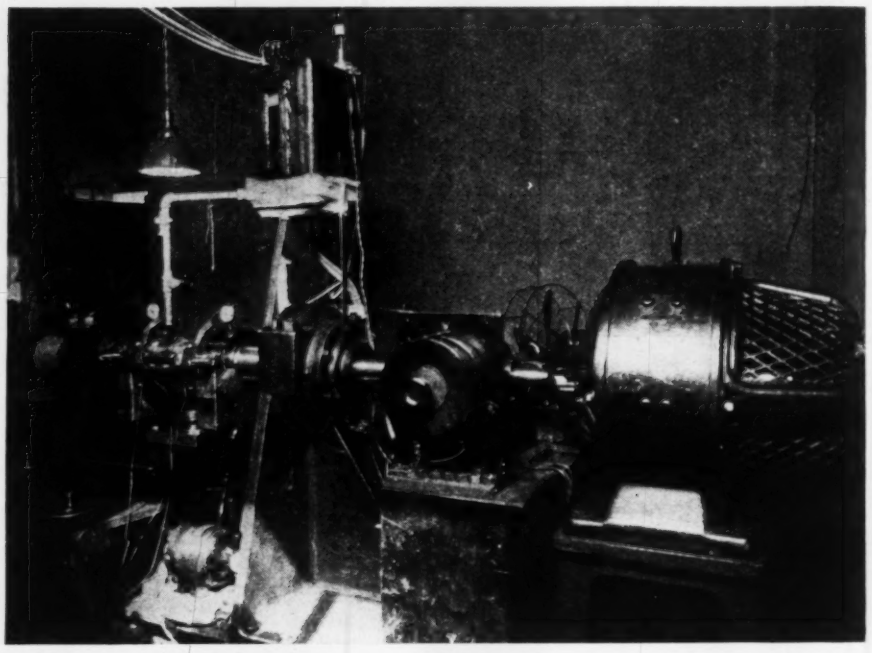

FIG. 1 GENERAL VIEW OF LUBRICATION TESTING MACHINE

[1] "Effects of Side Leakage in 120-Degree Centrally Supported Journal Bearings," by S. J. Needs, Trans. A.S.M.E., October, 1934, pp. 721–732.

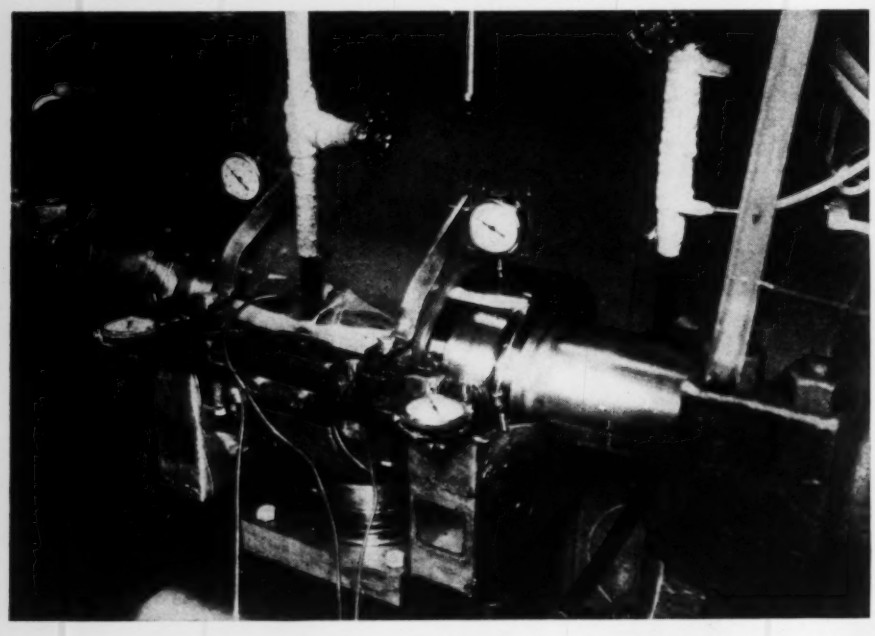

FIG. 2 CLOSE-UP OF BEARING IN TESTING MACHINE

The bearing-testing machine described in the Transactions of The American Society of Mechanical Engineers, 1926, p. 1190, was used. Figs. 1 and 2 show the general layout of the test. The test journal was 6.000 in. in diameter, machined with an accuracy of 0.0002 in. to 0.0003 in. The bearing used was a standard turbine bearing of 6 by 12 in. nominal size. The clearance, as measured, was 0.0094 in. (average of many determinations of bore diameter). Two annular end grooves brought the active length of the bearing to 9.5 in., symmetrical with respect to the center line of the bearing. The bearing was relieved at the horizontal split for 30 deg, leaving a central bearing of 120 deg.

The lower half bearing was mounted on the machine. It was assembled on

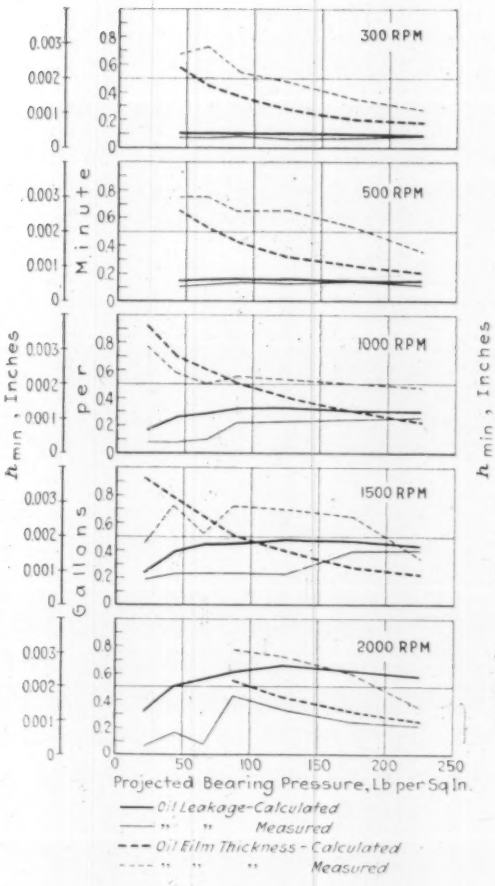

FIG. 3 COMPARISON OF TEST RESULTS AND CALCULATIONS
(Bearing 6 in. by 9.5 in. active length; 0.0094 in. diametral clearance; inlet oil temperature, 35 C.)

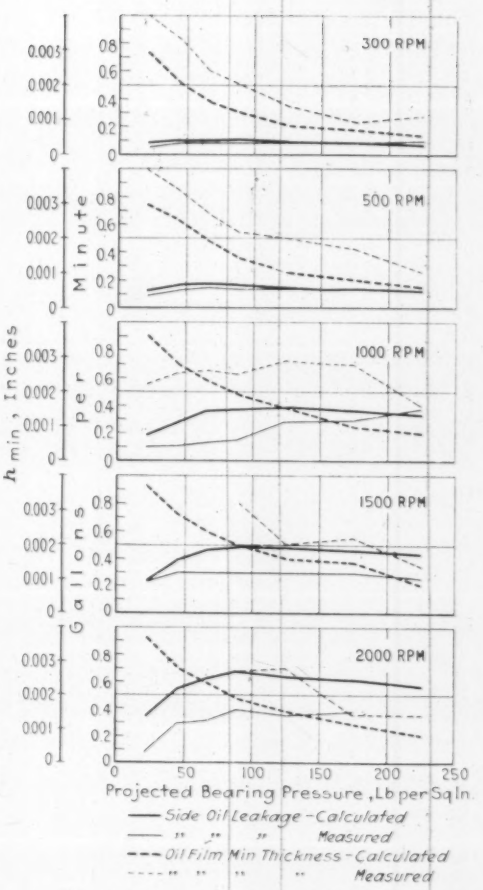

FIG. 4 COMPARISON OF TEST RESULTS AND CALCULATIONS
(Bearing 6 in. by 9.5 in. active length; 0.0094 in. diametral clearance; inlet oil temperature, 50 C.)

a spherically seated thrust ball bearing. This, combined with the loading feature of the machine, gave the bearing perfect freedom of adjustment to the journal, and the oil film was practically unrestricted.

The top half of the bearing was removed and replaced by a cover of transparent celluloid. The ends of the cover were sealed by oil throwers and ends fitted with very close clearance. Special dial indicators were mounted on the bearing. The difference in readings at rest and when running gave a direct measurement of oil-film thickness.

The temperatures of the bearing were determined by thermocouples opening into the oil film and mounted flush with the babbitt surface in small micarta plugs.

Light machine oil of 225 sec Saybolt at 100 F and 105 sec at 130 F, specific gravity 0.92, was used for the test. It was stored in the upper container (see Fig. 1) and kept at a uniform temperature. A heating coil and agitator were installed in the container. The oil was fed to the bearing by gravity through an insulated pipe. It was admitted into the beveled groove. The largest part of the oil was carried into the clearance by the journal, the excess flowing over into the annular grooves. This oil, together with the leakage from the bearing sides, was collected into two tin containers mounted on the bearing ends (Fig. 2). Celluloid windows allowed visual observation. The oil drained into a lower container, supplied with a cooling coil and agitator. An excess-capacity transfer pump from the lower to upper reservoir kept the levels practically constant.

Runs were made with loads of 1250, 2500, 3750, 5000, 7050, 9780, 12,620 lb, or projected-area pressures, respectively, of 22, 44, 66, 88, 150, 175, 225 lb per sq in. For each load, speeds of 300, 500, 1000, 1500, and 2000 rpm were run.

A run for each load and speed was made with an inlet oil temperature of 35 and 50 C. The test procedure was as follows: The machine was run several hours until a steady temperature condition was reached. The oil supply valve was then adjusted slowly till just enough oil was fed into the bearing to keep the bevel groove full without overflow into the annular grooves. (Any starving of the bearing could be detected by an increase of driving torque.) When thus adjusted, the return oil flow was collected into a graduated cylinder, directly giving the side leakage from the bearing.

The observed values of side leakage, together with the observed thickness of oil film, are plotted in Figs. 3 and 4. They are superimposed on the values computed by graphic interpolation from Table 2 of Needs's paper.[1] The observed quantities of oil are consistently smaller than the computed; they are generally of the same order. The more marked discrepancy in the oil-film thickness may be credited to imperfection of experimental set-up or to viscosity of oil film higher than recorded. However, the side leakage should be the same for different viscosities as shown in Table 2. It is the author's contention that part of the oil leakage is carried over by the shaft to the vacuum zone of the bearing, sucked into the clearance, and recirculated in the bearing. This would explain also the larger divergence between computed and observed values of side leakage at higher speeds, when the vacuum in the bearing is accentuated.

BOILER-STEEL EMBRITTLEMENT

A Critical Summary of Published Information

By EVERETT P. PARTRIDGE and W. C. SCHROEDER

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THE PARTICULAR type of boiler trouble generally characterized by cracking of the plates and rivets along submerged riveted seams has been known for many years as "caustic embrittlement" or simply "embrittlement." This phenomenon has caused more conflict of viewpoints among operating engineers and research investigators than almost any other disease to which boilers are subject. Aside from a discussion of boiler cracking by Hall in 1930, little, however, has been done to correlate the very considerable amount of information bearing on the subject. To supply this deficiency, the authors have collected information on record in the scientific and technical literature which may be significant in understanding embrittlement.

In attempting to organize the material in such a way that the broad significance of the various investigations would not be obscured completely by the details, it has been divided into four main parts and a final summary. Since embrittlement involves a selective chemical attack upon steel, the first part has been devoted to a discussion of the chemical reaction between steel and water, including the effect of various dissolved salts. The extent to which chemical attack in the absence of stress affects the mechanical properties of steel is considered in the second part of the survey. Since the mechanical properties of steel at boiler temperatures are not the same as at room temperature, this effect, entirely separate from that of chemical attack, is described in the third part. The fourth part is a review of the effects of combined chemical attack and mechanical stress upon the cracking of steel. The final summary includes suggestions for further experimental work.

The present article, which is intended to serve only as an abstract of the complete review, lists the conclusions reached by the authors from their examination of the more significant papers in the various fields just cited. These conclusions are subject to modification as further experimental work supplies information lacking at present. The review in complete form is to appear in *Metals and Alloys*.

CHEMICAL FACTORS IN THE ATTACK OF BOILER WATERS UPON STEEL

Examination of the chemical behavior of unstressed iron in water or various solutions, while not adequate in itself to explain embrittlement, does provide a necessary background for an understanding of the chemical factors in the embrittlement process. The considerations which seem most significant may be summarized as follows:

(1) In the absence of oxygen, water reacts with iron at ordinary or elevated temperatures to produce hydrogen and a coating of black magnetic oxide (Fe_3O_4) on the iron surface.

(2) The oxide coating acts as a mechanical barrier that tends to separate the iron from the water and thus to slow down the rate of reaction.

(3) Various substances in solution tend to destroy or strengthen the oxide coating, thus affecting the rate of reaction. Low concentrations of sodium hydroxide tend to maintain a coating with the greatest protective qualities. Increasing concentrations of sodium hydroxide, disodium phosphate, sodium nitrate, and sodium chloride decrease the protective effect, in contrast to sodium sulphate, which apparently tends to produce a highly protective coating.

(4) When several substances are present in solution, the net effect may differ from that anticipated from the effects of the individual constituents. Thus the protective action of sodium sulphate against attack by sodium hydroxide is offset by the addition of sodium chloride.

(5) Any discontinuities in the oxide coating will accelerate localized chemical attack.

EFFECT OF CHEMICAL ATTACK UPON THE MECHANICAL PROPERTIES OF LOW-CARBON STEEL

Because hydrogen is produced inevitably whenever water or an aqueous solution comes in contact with steel, particular attention has been directed to the brittleness produced in steel by dissolved hydrogen. From a consideration of experimental results the following general conclusions are offered:

(1) The normal solubility of hydrogen in iron over the range of boiler temperatures is estimated to be very low. The solubility in general increases with temperature and pressure.

(2) Quantities of hydrogen greatly in excess of the ordinary solubility may be absorbed by steel during chemical reaction at the surface of the metal, the hydrogen diffusing readily into the metal as if it were under an extremely high gas pressure.

(3) Hydrogen absorbed by steel during chemical reaction at the metal surface diffuses out of the steel when the chemical reaction ceases.

(4) The rate of diffusion of hydrogen through steel, both into the steel during chemical reaction at the metal surface and out from the steel after reaction has stopped, increases with temperature.

(5) Steel which has absorbed hydrogen behaves in a brittle manner, the elongation and number of bends required to produce failure being decreased markedly, although the tensile strength is practically unaffected.

(6) Steel which has been embrittled as a result of the absorption of hydrogen regains its ductility when the hydrogen is removed, but the recovery generally is incomplete. The permanent impairment in properties may be due to reaction of the hydrogen with some of the minor constituents in the steel.

(7) Only a low concentration of hydrogen in steel, much below that which may be produced by chemical reaction, is necessary to cause brittleness.

Published by permission of the Director of the U. S. Bureau of Mines. This article is an *abstract* of a detailed study, presented at the Annual Meeting, New York, N. Y., December 3 to 7, 1934, of The American Society of Mechanical Engineers, in connection with an investigation conducted under a cooperative agreement between the Joint Research Committee on Boiler Feedwater Studies and the United States Bureau of Mines. The general investigation is supervised by a subcommittee of which J. H. Walker is chairman, and is carried out at the Nonmetallic Minerals Experiment Station of the Bureau of Mines, maintained in cooperation with Rutgers University at New Brunswick, N. J. The interpretations and comments are those of the authors, and the summary as a whole is to be regarded as a report to the subcommittee rather than by the subcommittee.

(8) Whether or not a specimen of steel will be embrittled by an aqueous solution may depend largely upon the degree to which the solution removes or prevents the formation of the protective coating of oxide on the metal surface.

(9) Direct inter-granular corrosion of steel by a boiler water or its concentrated saline may be possible but has never been definitely demonstrated.

(10) Selective corrosion of steel subjected to repeated or reversed stresses may lead to ultimate failure by fatigue.

MECHANICAL PROPERTIES OF LOW-CARBON STEEL AT BOILER TEMPERATURES

No approach to the embrittlement problem from the viewpoint of chemical attack can afford to neglect the variation in properties of steel with change in temperature. In this connection it should be remembered that:

(1) The tensile strength of ordinary low-carbon steel is greater and the ductility is less at boiler temperatures than at room temperature.

(2) The increased tensile strength, decreased ductility, and step-shaped stress-strain curve of low-carbon steel at boiler temperatures are results of the same changes in steel responsible for aging after cold work.

(3) Any mechanical test of chemical attack upon steel should be considered with respect to the properties of the steel at the test temperature.

CRACKING OF LOW-CARBON STEEL UNDER COMBINED CHEMICAL ATTACK AND MECHANICAL STRESS

From the large number of more or less contradictory details in the literature, certain important generalizations may be derived:

(1) The cracking of steel subject to chemical attack while under stress consistently commences in a region where the local stress is greater than the average.

(2) An unknown but probably very high local stress is necessary to initiate cracking.

(3) The yield point at room temperature is not a fundamental criterion of the stress necessary to cause cracking.

(4) The time required to break steel in tension while in contact with a concentrated solution of sodium hydroxide at an elevated temperature is not a direct measure of a rate of chemical attack.

(5) Most steels are subject to embrittlement, although there is some question concerning a possible greater resistance in the case of non-aging steel.

(6) When the steel is subjected to repeated stress in contact with sodium-hydroxide solutions at boiler temperatures, both hydrogen embrittlement and corrosion fatigue may play important parts in producing failure.

(7) It may be possible to prevent cracking of boiler metal, whether due to hydrogen embrittlement or corrosion fatigue, by the maintenance of protective coatings on the steel produced by the addition of specific chemicals to the boiler water.

MECHANISM OF EMBRITTLEMENT FAILURE

A fundamental distinction must be made between two possible ways in which mechanical stress may produce failure in conjunction with chemical attack. On one hand, it is possible that mechanical stress accelerates a highly localized corrosion. On the other hand, it is equally possible that mechanical stress simply causes the ultimate cracking of steel previously made brittle by the absorption of hydrogen. In the first case, stress is essential in producing dangerous chemical attack; in the second, the chemical attack leading to a brittle condition is relatively independent of stress, except as the latter may tend to break a protective coating on the metal.

No very definite evidence has been found to support the theory of inter-granular corrosion, although the possibility of selective attack of this type as a special case of corrosion fatigue must be kept in mind. The experimental results used in support of the theory of inter-granular corrosion generally may be used also in support of the theory of hydrogen embrittlement.

A thoroughly logical picture of the way in which the failure of boiler steel may be caused by hydrogen embrittlement may be built up on the basis of the information discussed in this report. When a boiler goes into operation its internal surfaces immediately are covered with a layer of magnetic oxide. Under ordinary conditions this layer forms an almost impassable barrier between the boiler water and the steel. As the concentration of hydroxide increases, however, the layer becomes progressively less protective, and the reaction between the water and the steel increases its rate. This chemical reaction produces hydrogen, which diffuses into the steel and causes a definitely brittle condition, possibly by setting up internal stresses at grain boundaries and cleavage planes.

Although the steel may be rendered very brittle by the absorption of hydrogen, no serious permanent damage is done until a localized stress at some point reaches a very high value, probably well up toward the ultimate strength of the metal. A piece of normally ductile steel subjected to a high local stress of this sort would yield slightly, automatically reducing the local stress by distributing it over a large section of metal. The embrittled steel, however, instead of gliding along slip planes in the manner of ductile metal, ultimately will crack at the point of high local stress. Although the initial failure may be only the boundary between two grains in the outermost surface layer, it represents permanent damage to the steel. The high local stress, instead of being reduced in intensity, then may be transmitted to the next layer, with the result that the failure is eventually repeated here. As long as the concentration of hydrogen in the steel is sufficient to maintain it in a brittle condition, and as long as the local stress in the outermost sound layer of metal is sufficient to cause failure, the process of cracking will continue.

In applying this concept to actual conditions in a boiler it should be remembered that the stresses in riveted seams are not simple tension stresses. Instead they are much more likely to include bending stresses in which a certain portion of the surface metal is subjected to a stress greatly above the average stress on the whole cross-section. Such a condition might assist in the process of chemical attack by damaging the protective oxide coating, in addition to its purely mechanical effect in causing failure of embrittled metal.

When water alone is in contact with steel, the oxide coating so greatly retards the rate of reaction that the hydrogen liberated is insufficient to produce any marked embrittlement at room temperature. It is, however, barely possible that at elevated temperatures in a boiler the rate at which hydrogen is evolved by an ordinary boiler water would be sufficient to produce a noticeable increase in brittleness of the boiler steel.

The theory that hydrogen embrittlement may be responsible for the failure of riveted seams and expanded tube ends, like all logical theories, may be proved incorrect by subsequent experimentation. Careful investigations of its validity by tests under boiler conditions is a matter of greatest importance if a rational basis for the prevention of embrittlement failures is desired.

PREVENTION OF EMBRITTLEMENT FAILURE

As has been noted, the oxide coating inevitably formed on the steel surfaces of a boiler in contact with water normally pro-

tects the metal from further reaction to produce hydrogen, except at a very slow rate. If, however, conditions allow the concentration of an alkaline boiler water in riveted seams, the protective effect of the oxide coating in these seams ultimately will be affected, with resultant acceleration of the rate at which hydrogen is liberated at the steel surfaces. An increase in sodium-chloride concentration presumably will have a similar effect.

Sodium sulphate in solution, even in small quantities, at first will tend to maintain the protective layer against the action of sodium hydroxide, but as the concentration of the latter builds up, particularly if sodium chloride is also present in appreciable amounts, the beneficial effect of the sulphate will disappear. The rate of attack of the saline solution on the metal in the riveted seam therefore will increase as the solution concentrates. The process of concentration furthermore will tend to be accelerated by the decomposition of water to liberate hydrogen. Unless some additional factor enters the situation, the rate of reaction between water and steel therefore will tend to increase indefinitely. If, however, some other protective layer, stable in contact with the saline solution, can be deposited upon the steel, the self-accelerating reaction between the steel and the solution may be retarded or even stopped.

The new protective layer might be produced on the steel by the chemical action of some hypothetical substance added to the boiler water, or it might result simply from the precipitation of a continuous, impervious deposit of some dissolved substance such as sodium sulphate or the less soluble constituents commonly found in boiler scales. It is perhaps pertinent to point out that embrittlement generally has occurred in boilers operating with boiler waters distinguished for their freedom from scale formation.

In any case, the prevention of embrittlement failures, in so far as it may be accomplished by control of water conditions, must depend fundamentally upon maintaining a stable, self-repairing coating upon the steel which effectively separates it from contact with the water.

An investigation of the behavior of the various coatings which might be produced by the addition of specific substances to the boiler water is probably the most important step which can be taken in the attempt to prevent embrittlement failures from the standpoint of boiler-water control. Because of the favorable indications from laboratory experiments and the increasing use of sodium phosphate as a water-conditioning chemical for other purposes, the possibility that this substance may assist in maintaining a stable protective coating demands particular attention.

PROGRAM OF RESEARCH

In a study of various sodium salts the solubility relations in complex solutions have already been determined. The effect of solution composition upon cracking of boiler steel is an extension of this study with the following immediate objectives:

(1) To determine the lowest concentration of sodium hydroxide which is more effective than water alone in producing failure of boiler steel.

(2) To determine under what conditions sodium sulphate is effective in reducing or preventing the attack of boiler-water salines upon steel.

Further extension of the work to include the effect of other substances present in boiler waters is contemplated. It is hoped that a rational basis for control of boiler-water composition to prevent embrittlement failure may result from this investigation.

The Pivoted-Motor Drive

(*Continued from page 291*)

The work may be checked by measuring e and p. If correct, $We = Gp$.

It is evident that A and B are possible positions of the pivot, since each of them is a point about which W and G have equal moments. Furthermore, from Equation [10], the locus of the pivot is a straight line, since for a given load and speed and given value of R, this expression is a linear relation between the variables e and h, all of the other quantities in it being constants.

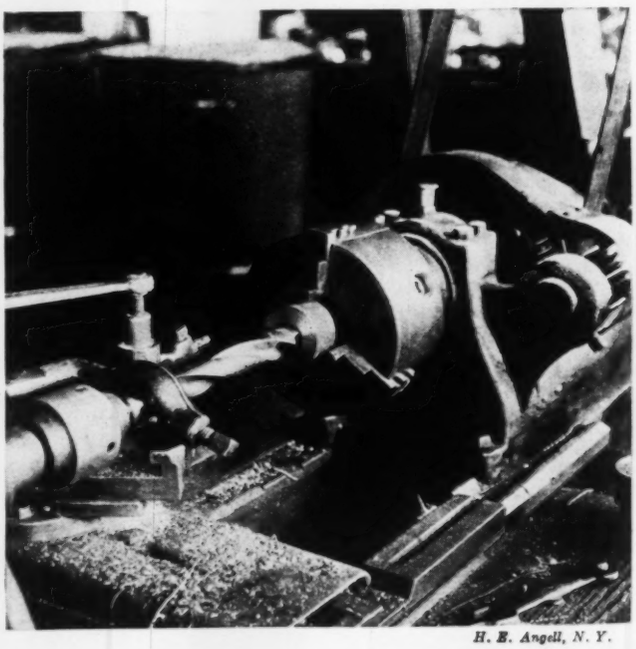
If the value of the idling tension is desired, it may be obtained by constructing the resultant at zero load, which lies along the line joining the shaft centers. Measuring p_0, the perpendicular on this line from Q, $p_0 = 14.5$ in the present case. Hence, if T_0 is the tension in each strand at no load, and G_0 their resultant, $G_0/W = e/p_0 = 7.8/14.5$, or $G_0 = 393$. Resolving this along one of the belt strands, $T_0 = 210$ by measurement. The value previously computed is 209.

Returning to the line AB, the locus of Q, the position of the pivot for any specified value of h is to be found by drawing a horizontal line at distance h below the motor shaft, the intersection of this line with AB being then the pivot position which will give the desired tension ratio at the peak load.

Bases with relatively large values of h operate near the position of Q shown in the figure. Bases with smaller h operate somewhere about A. Either position will give the desired tension ratio at the peak load, but when Q is close to A the tension will vary more with the load than when Q is farther from A.

There are practical limits to the location of Q. Negative values of e are obtained when the pivot is above the point A on the locus, which means that the motor will fall over toward the driven shaft, initially, the idling belt tensions in such cases coming out negative, so that they are pushes rather than pulls. On the other hand, the maximum value for e is limited by the length of the base arms. The designer may guard against overloading the bearings by noting the value of the resultant G.

The broken lines intersecting at A' in Fig. 8 are the resultant and the locus of Q for the case of reversed rotation of the motor, in which the tight belt strand is above.



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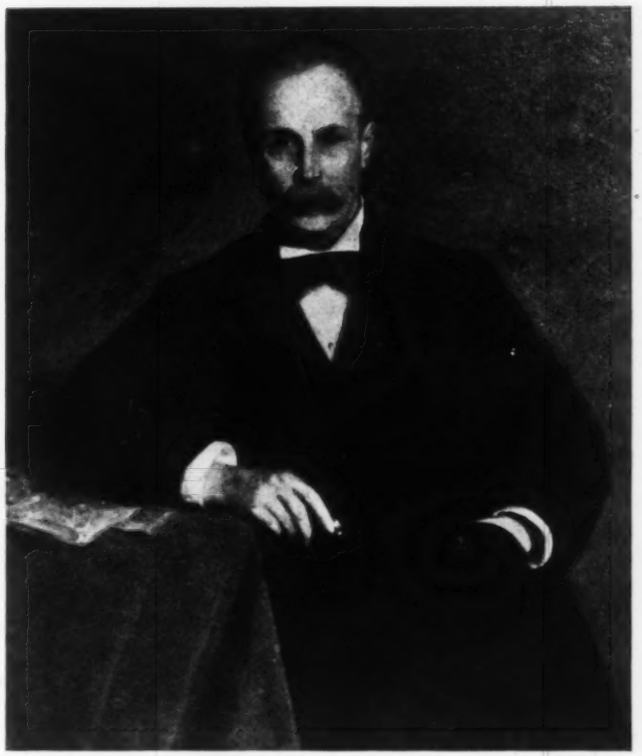

FREDERICK WALTON

FREDERICK WALTON

Inventor of Machinery for the Manufacture of Linoleum and Founder of the Linoleum Industry

By WILLIAM B. COLEMAN

BLOOMFIELD, N. J.

THE birth of Frederick Walton on Thursday, March 13, 1834, at Sowerby Bridge by the River Calder, England, caused only a slight pause in the inventive activities of his father, James. His mother, Ann Kenworthy Walton was, however, concerned for he appeared to be a small delicate baby. Frederick was their second boy, their third child. They were to have ten children.

James had made money, much money, by his invention of a machine for frizzing wool. The method of hand frizzing wool, so that the fibers on the surface were curled up like little pimples, was known only to four or five families of England, one of which was the Walton family. James's father and grandfather had been frizzers and cloth drapers. James's conception of a machine for doing this work was frowned on by his father; he would have none of it; the old way was good enough for him. Determined to make such a machine, James left his father, obtained capital from friends in nearby Halifax, and built a machine which failed. Calm reflection disclosed the weakness and the second machine was a success. He was soon a moneyed man.

This success encouraged other experiments and he made several improvements in cloth-finishing machines.

Two weeks after Frederick was born his father, James, applied for a patent on a new method of making wire cards—a patent which was to engage him in a bitter struggle and to cost him his fortune. Wire cards are essentially wire brushes mounted on a cylinder whose function it is to parallelize the fibers in the preliminary stages of the spinning of cotton. Frederick's father's invention consisted of replacing the usual leather backing of the wire pins with india-rubber. The disadvantage of the leather was that it became hard and the pins would then be broken. James while idly pricking a piece of india-rubber with a pin noted the ease of the pin's action in every direction. He realized that this new material, called india-rubber, would be vastly superior to the leather used. For disclosing this invention King William IV of England granted to James Walton his patent protection for a period of years.

Frederick was three years old when his father, in honor of the Coronation of Queen Victoria, gave a dinner to all the worthies

of Sowerby Bridge, under a 180 by 210 ft tent which he himself had designed and erected.

By the time Frederick was four his father had patented improvements on Dyer's card-making machine. James's machine cut off the wire, bent it into the form of a staple, punctured holes in the material to receive it, inserted it in the holes, and shaped the wire, at the rate of 240 per minute.

The big spinners at Halifax were not long in helping themselves to the idea embodied in James Walton's patent of using rubber as a backing for wire cards. James and his partners sued. In a series of court actions lasting nearly four years, which was one of the causes célèbres of the time, five judges upheld the validity of the invention. In June, 1842, when Frederick was eight, Lord Denman, on new evidence given by Michael Faraday, reversed all the previous decisions. Licenses were granted to thirteen firms by the court on the condition that they would pay the Queen the cost of the trial. James was thoroughly disgusted with the workings of justice in England and he resolved never again to take out another patent. He never did.

But that was not the end of Frederick's father. All the injustice of the law was soon to be set aside by the inherent peculiarity of the rubber itself. Under the influence of the heat of the carding room it was found that the rubber would, in time, soften and that all the cards which both sides had sold during this controversy were failures. Being a man of honor James gave all his customers notice he would replace the wire cards he sold them. He also took over the obligations of the firm, promising to pay his partners for their share of the cards rights. Then he set about to find out what caused the failure of the rubber. In a short time he found it. Now he could make a card without the old disadvantage. The secret was kept for ten years during which he became the greatest wire-card manufacturer in the world.

EARLY EDUCATION

Frederick's schooling at the village clergyman's was interrupted by Chartists' riots when the mob came to the windows with loaves on sticks demanding bread, for bread was very scarce then. His education there was all that he received outside of his father's machine shop and factory. He must have been a very observant son and this pleased his father greatly.

When 22, after having traveled alone on the Continent for his father's business, he became a member of the firm of James Walton and Sons. At his father's suggestion Frederick experimented and succeeded in making clothes brushes and hair brushes by mounting bristles in india-rubber. This was to start him off on a life of invention. To replace the india-rubber he made use of a compound of shellac and fibers. He improved his father's wire-card invention by simply substituting a single piece of wire for the staple-shaped wire his father employed. His shellac composition he made into sheets and seasoned as a floorcloth; he molded it into shapes of knife handles and a dozen other uses. Returning from Italy he tried his hand at making an artificial leather for bookbinding, but he couldn't make a varnish for coating the fabric which would dry quickly enough to be used in his machine. In attempting to find such a varnish he became familiar with paint skins in the form of predried linseed oil. He didn't succeed in making the varnish but he realized that he had found a new elastic mass, like, yet unlike, rubber, for which he saw a bright future. This idea he took to his father who acted toward Frederick just about the way his own father had treated him some thirty years before. James was tired of all this experimenting by Frederick, his jumping from one thing to another, wasting money on experiments that were never successfully concluded. With a determination very much like his father's, Frederick left the family seat of Haughton Dale; the partnership of James Walton and Sons was broken up, and with his share of the capital in cash Frederick set out to find a use for his new elastic mass.

After three years filled with ponderous difficulties, of begging and borrowing from his father, brother, and others, of nervous anxiety and sickening setbacks, Frederick discovered the best use for his oxidized oil in the making of a soft, durable, and sanitary floor covering which he named linoleum.

The future of this new floor covering was grasped by Taylor, Hill, and Nicholson who, with Walton, formed the Linoleum Manufacturing Co. at Staines, England.

His goal accomplished Frederick and his father were reconciliated. They were closer now than ever before.

At Staines, where the new company's plant was located, Frederick had to devise mechanical means of obtaining large quantities of this new oxidized linseed oil. This meant erecting special buildings, designing a pump to handle the linseed oil, and providing regulated heat for the building. This oxidized oil had to be mixed with rosin and kauri gum in steam-heated kettles which had to be designed and made. Waste cork from bottle-stopper makers had to be ground. It was always catching fire and several times nearly burned down the wooden mill. Huge bales of burlap had to be handled and a machine made to starch it. Then larger and wider roller calenders had to be made than were ever made before, to mix the linoleum cement, cork, and pigments and to form it into sheets on a backing of burlap. What a job this was! The cork would fly everywhere and just would not mix. The back of the linoleum had to be painted mechanically. The processed linoleum had to be seasoned in heated rooms for 10 to 30 days; whether to lay it on shelves or hang it in festoons was another problem. All this fell upon the shoulders of Frederick Walton to solve. That he solved it is clearly shown, for 54,000 square yards were made the first year. Production tripled the next year and for each year for a decade Walton had to provide for a steady and healthy growth. Whenever anything went wrong it was Frederick's fault and it seemed that only he could correct the trouble.

The directors frankly told Walton they couldn't do without him.

Toward the close of 1868, Frederick, while still keeping a watchful eye on the linoleum plant, patented a system of house construction based on an idea furnished by his father. Then, as now, a low-price adequate dwelling was looked upon as one of the pressing needs of the working man. Queen Victoria was much interested in the solution of this problem. James wanted it to be free but Frederick, a great believer in practical benevolence, thought that more use would be made of it if it was patented and a company formed to promote it. Two workman's cottages were built, newspapers wrote about it, philanthropical societies were interested, but nothing ever came of it.

PRINTED LINOLEUM INTRODUCED

In the beginning most of the linoleum was in plain solid colors, but in answer to the demand, printed linoleum was introduced. This was manufactured by hand block printing in much the same manner as floor oil cloth had been printed for a century previous to this year of 1868. The printers were independent fellows, invariably too drunk for work on Monday. By careless workmanship they often ruined much valuable linoleum. Sales had increased to such an extent that the directors agreed to allow Walton to build a machine to do this printing. He had often cautioned the printers that unless they were more careful with their work it would be necessary to build such a machine. They smiled at what they thought was an idle boast

for they knew that many had tried to make such a machine without success.

Walton did succeed in making the first practical floor-covering printing machine. The first one was built behind a partition in the same room where the printers worked. The machine in printing made a noise similar to the sound of the blow of a hammer and other workmen would unkindly josh the printers that another nail was being driven in their coffin. As indeed it was for the perfected machine did the work of 60 men and boys.

While developing this printing machine Walton patented with John Jones a machine for forging nuts, which cut the blanks, shaped them, punched their holes, and delivered them ready for tapping. At first it appeared like a great money maker, but after two years it was a fiasco.

Linoleum being in demand abroad, Walton, in 1872–1874, built the first plant in America on Staten Island, N. Y., while others were erecting the first plant in France.

WALL COVERING OF LINOLEUM

On the voyage home Walton thought of the idea of making a wall covering of linoleum. When the affairs at the linoleum manufactory were running smoothly he rented a small factory near his home which was to be the birthplace of "Lincrusta-Walton," the first linoleum wall covering. In the first experiments in order to emboss a pattern on the warm unseasoned linoleum composition he had a sculptor engrave a pattern on a slate cylinder. The result was a success. Walton formulated the composition for use in his "Lincrusta;" designed and erected the machines and factories to make it; financed it practically alone; established plants in England, France, and Germany; and sold the patent rights for America. The machine which he invented for this purpose calendered the linoleum composition on the paper or fabric backing, embossed a pattern on the surface, trimmed it, cooled it, and printed on it in three colors.

Five years after his first experiments he wrote to his father (a year before his father's death in 1883), ". . . . at the hotel we saw Lincrusta nicely fixed in the dining room—I also saw it the other day at the Queen's Hotel, Manchester, and in the new salon carriages of the London and North Western Railway Company—which are very handsome. We have received some large orders from America and business is very good on the whole. . . ."

"Lincrusta-Walton" proved to be a very popular material and the business prospered for many years until the vogue for highly ornamental furnishings waned.

STARTS ON MOSAIC-INLAYING MACHINE

A quarter of a century of association with the Linoleum Manufacturing Co., Ltd., was terminated in 1888 by mutual consent. Walton wanted to build a mosaic-inlaying machine but the directors didn't and they gladly released him from his contract. They probably thought he was too old to be of any further use to them and his salaries and royalties then amounted to £1600 to £1700 per year. Frederick was as happy as a school boy at vacation time to be free again so that he could start on what was to be his magnum opus—his automatic straight-line inlaying machine.

This mammoth machine was not to be finished for sixteen years. It is doubtful if 54-year old Frederick Walton realized the magnitude of this undertaking for it is difficult to think of one man with the courage to tackle such an overwhelming task almost single handed.

His first attempt was patented in 1882. In the working of this machine the sheets of different colored linoleum were cut on cutting blocks all formed from a composing plate so that the various pieces of cut linoleum would fit neatly together to form the desired pattern of the inlay. The cutting blocks were so arranged that the linoleum composition in sheet form was pressed against the knives of the cutting blocks from the top. The unwanted tesserae were rejected by pushing them through openings in the cutting blocks while the wanted pieces of cut linoleum were retained on the blocks. The linoleum sheet and the pressing mechanism were then automatically raised up out of the way and the filled cutting block swung through an arc of 180 deg to deposit the wanted tesserae on the fabric backing. As the cutting blocks return to be filled again the linoleum composition and the partially inlaid fabric moved forward on an endless belt a distance equal to the interval of the design. The other colors were inlaid similarly until the pattern was completed when it was pressed to the backing and together so that there was no opening between the different colored pieces. The method of preparing the cutting blocks all from the one composing plate was an intricate and cunning device. This was the machine which the directors of the Staines Linoleum Manufacturing Co. would not agree to let Walton make.

On his own now he changed this machine and in his second patent in 1888 he described an eight-color octagonal inlaying machine. In this case the cutting blocks so ingeniously contrived for the first machine were mounted on an octagonal prism which revolved intermittently on a horizontal axis. The sheet of colored linoleum composition was placed on the cutting blocks by hand, at the next step of the prism, at which this block would be at the highest side of the octagon, the sheet was mechanically pressed against the knives of the cutting blocks, two steps later the unwanted tesserae were rejected, and two steps further when this block was directly over the horizontally placed backing fabric the wanted tesserae were deposited thereon. With each step a new color was laid on until all eight colors were inlaid to form a section of the pattern and the octagonal prism had completed a revolution. Then the fabric backing moved forward a step. Several steps later the inlaid pieces were pressed together and to the backing or embossed. The backing was thin linoleum composition calendered on burlap, a method in vogue today.

The stopping and starting of this huge octagonal prism made such a vibration that the frame was soon badly strained, finally breaking down. The jarring effect of the intermittent action was too severe to overcome. The inlaying had to be a continuous action and this meant a circular cylinder. All previous work had to be discarded and Walton had to start anew.

He soon realized that he couldn't carry the financial burden alone. In 1895 the Greenwich Inlaid Linoleum Co. (F. Walton's new patents) was formed.

PATENTS FIRST INLAYING MACHINE

This time he was on the right track. In 1890 (B. P. 16,043) he patented his first continuous inlaying machine. This is partly shown in Plate 1. The cutting cylinders *H* were later much improved and they are illustrated in detail in Plate 2 (B. P. 198/1897). In Plate 1, Fig. I, *B* is an iron cylinder, approximately 14 ft in diameter and approximately 7 ft long, having a large number of pins projecting from its circumference, which project just far enough to pass through the backing and to enter but not pass through the linoleum tesserae placed on the backing. This pin drum rotated in a counter-clockwise direction. The burlap backing was carried on the endless belt *G* and was pressed against the pin drum by the roller *E*. The burlap was carried by the pin drum under the cutting cylinders *H*. The cutting cylinders, Plate 2, had projecting knives, a^2 shaped and arranged according to the pattern, and in the spaces between the knives there were radially sliding pis-

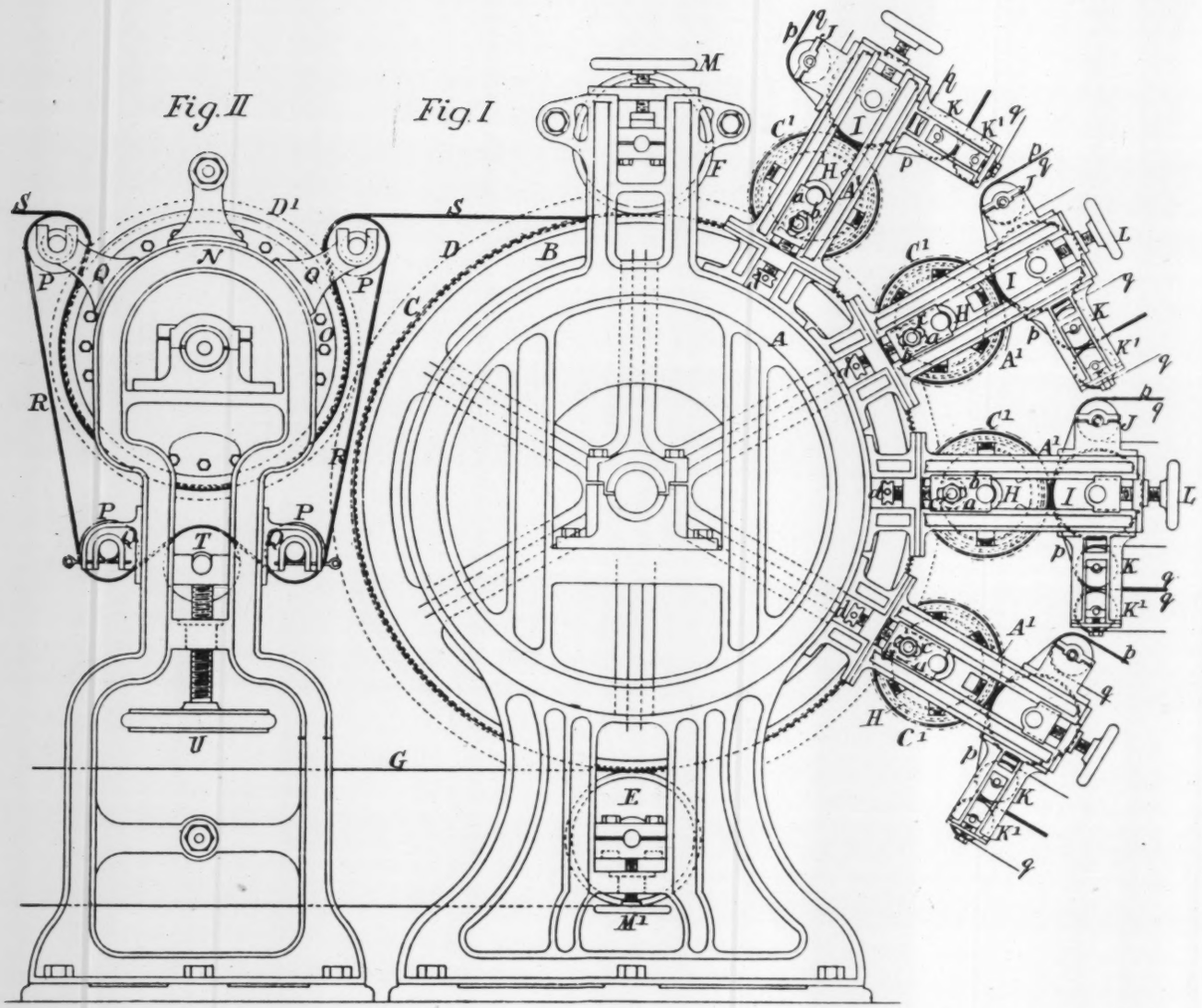

PLATE 1 FROM WALTON'S BRITISH PATENT 16,043, OCTOBER 9, 1890

tons or plungers to push out the linoleum composition. Fig. 4 of Plate 2 shows the mechanism for rejecting the unwanted tesserae and Fig. 5 shows the working of the pistons for inlaying the wanted pieces of linoleum composition. The sheet of colored linoleum composition was pressed against the cutting cylinders by roller *P* so that the whole sheet was cut into tesserae, filling all the spaces in the circumference of the cutting cylinder. As this cylinder turned around clockwise the stems of the plates which form the bottoms of the tesserae spaces from which the tesserae were to be rejected were acted upon by pins *b* of eccentric cylinder *B* so as to push these unwanted tesserae quite out of the spaces they occupied. These tesserae were cleared away by the revolving brush *G*. As the cutting cylinder continued to revolve until it came into line of contact with the main pin drum, *K* in Plate 2, all the plates are pushed out by cylinder *C*. The wanted tesserae were in this manner inlaid on the burlap backing *L* carried on the pin drum *K*. Further on in the revolution of the cutting cylinder all the plates were pushed out slightly beyond the knive edges. Here they were lubricated by a plush covered cylinder *H* served with a lubricant such as petroleum spirits so that the tesserae would not adhere to them. In like manner the other linoleum sheets of different colors were arranged on the burlap backing by the other cutting cylinders until the design was completed. The projecting pins kept the tesserae in proper position until they reached the pressing drum, Fig. II, Plate 1. The inlaid pieces of linoleum were pressed against a heated cylinder while a continuous rubber blanket *R* was interposed between the pressing rollers and the sheet. To prevent the sheet from adhering to the heated cylinder its surface was lubricated with paraffin wax. The inlaid linoleum *S* then traveled over cooling cylinders until it was hard enough to be rolled into large rolls, taken to another building, and hung in festoons to season. The machinery for preparing the continuous sheets of various colored linoleum and supplying them to the inlaying machine at the correct speed were housed on the upper floors over this machine.

With this new inlaying machine, if three colors were to be in the pattern, three solid sheets of linoleum composition had to be made, of which two-thirds of each sheet would be unwanted or rejected as waste from the inlaying machine. For the machine to be economically feasible these rejects had to be

used over again. For doing this Walton designed a series of corrugated cylinders. But to be successful he had to change his linoleum cement so that it could be used and reused. He had to find a new way to make his oxidized oil, as the pieces of scrim cloth would foul the cutting knives. This he did by blowing air through oil in a jacketed kettle equipped with stirring tines. But this blown oil did not have the same elastic properties of the old air-dried oil made by the original process. It did have more adhesion and this was needed in the cement so that all little pieces of mosaic would bind together. A combination of the two oils worked fine and was cheaper. The entire process had to be revamped.

Each pattern had to have a complete set of cutting cylinders, if it had three colors that meant three cutting cylinders all exactly alike. Such a set was very expensive to make. In order to eliminate the need for a new set for each change of pattern Walton invented a set of cylinders which could be used for a great variety of geometric patterns, simply by changing the order of rejection. A set of cutting cylinders were made with 1/4-in. squares all over the surface. Each square was made so the pistons between its boundary of knife blades could be motivated independently of each other. With such a set, a checker-board pattern from 1/4-in. squares to 12-in. squares could be made. A basket-weave effect and a great many other designs were readily available. Each of these cutting cylinders contained over 45,000 squares each outlined with cutting knives and with an independently operated plunger between the knives and all the squares on all three cylinders had to be exactly alike.

Springtime 1904 the task was completed, the machine was working satisfactorily, and seventy-year-old Frederick Walton expected to retire to a well-earned rest.

Today there are seven of these machines in the world, three are in America. To build such a machine would cost well over a million dollars exclusive of a seven-story building to house it. Another half million dollars would have to be expended just for making sufficient sets of cutting cylinders to allow a desirable variation in the line of linoleum patterns.

Walton considered this machine to be his greatest achievement. He was very proud of it. A well-known engineer who saw it for the first time that May, 1904, said, "I cannot understand any man having the audacity to undertake such a piece of work." It is a fascinating thing to watch this 6-ft-wide ribbon of beautiful colored mosaic linoleum come rolling out of the machine, a half mile an hour, every figure perfect, every line true. A few men around checking this and that, but no one doing any laborious work. This first fully automatic inlaying machine was completed forty years after Frederick, by courageous perseverance, had founded the linoleum industry. If Walton had not invented this machine it probably would not have been invented at all.

HIS OTHER INTERESTS

About the time he was starting his work on the inlaying

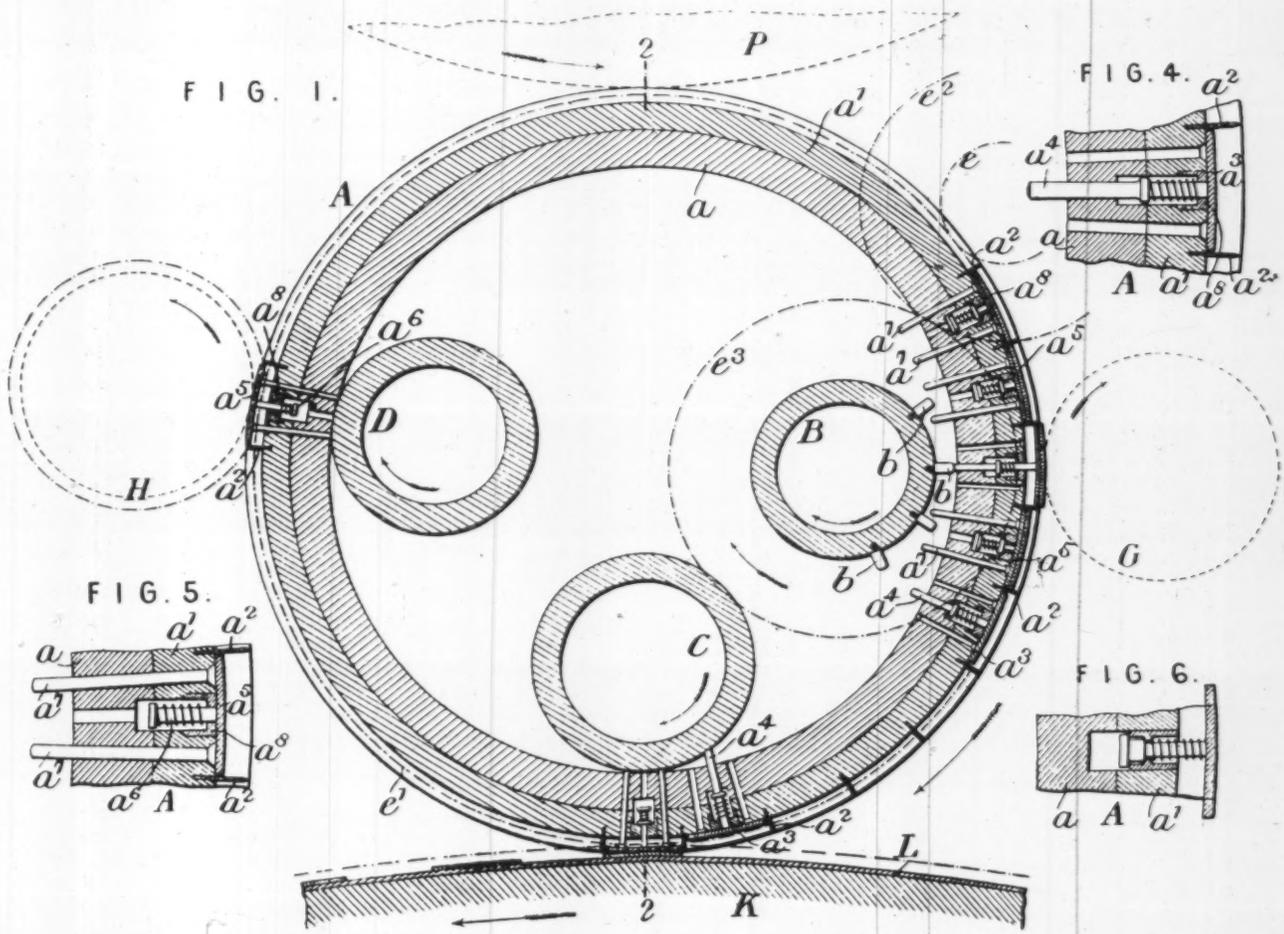

PLATE 2 FROM WALTON'S BRITISH PATENT 198, JANUARY 4, 1897

machine Walton started, in a very small way, the manufacture of flexible metal tubing. He had acquired all the patent rights from its inventor, the Frenchman, E. Levavasseur. Levavasseur was a Paris jeweler, maker, since 1872, of snake bracelets and necklaces of gold and silver. These were made of a corrugated ribbon of gold or silver, interlocking in each helical convolution. Levavasseur was profitably employed in their manufacture under patent protection when in 1886 he was walking in Paris and noticed the curious device they had for washing the streets. It consisted of "short lengths of piping carried on a pair of small wheels fore and aft and joined together by copper-riveted leather hose to secure flexibility." He thought this a clumsy affair for that mechanical age and he felt he could use the principle of his snake necklace for making a flexible tubing. At first, attempts were made to make this tubing waterproof by inserting rubber strips between the joints. But the rubber soon came out or deteriorated. Walton substituted a thread saturated with linseed oil. But a corrugation was finally devised which was not only waterproof but suction-proof. Under Walton's vigorous guidance the United Flexible Metallic Tubing Company became a great success and an important industry. Walton patented methods of applying this tubing as armoring for electric conductors—ghosts of the B. X. cable of today.

Seventy-year-old Walton did not retire for long. He went to his beloved Epieux in France for fishing and sketching. One day while riding in one of the novelties of the day, an automobile, a tire blew out, there was a bad skid, though it did not result in a serious accident it thoroughly frightened Walton.

In a year he was back in London, busy devising and inventing some way of providing wheels for motor vehicles which would have the advantages of pneumatic tires without the disadvantage of the liability of puncture. He hit upon the idea of using a solid tire for contact with the road and interposing a pneumatic tire between the body of the car and each wheel. The pneumatic tire not being in contact with the road was not subject to being punctured and at the same time the body of the car rested on these pneumatic tires. This work was to engage his interest for the next seven years, during which he obtained thirteen more British patents. In 1913 he had to stop for fear of beggaring his family.

During the World War he patented a system of wing construction for aircraft so that they could be made without the use of wood.

Walton had hoped to live to be 100—it was one of his last ambitions. He might have if he had not fallen and broken his thigh. Several weeks later he died on May 16, 1928, in Nice, France, at the age of 94 years.

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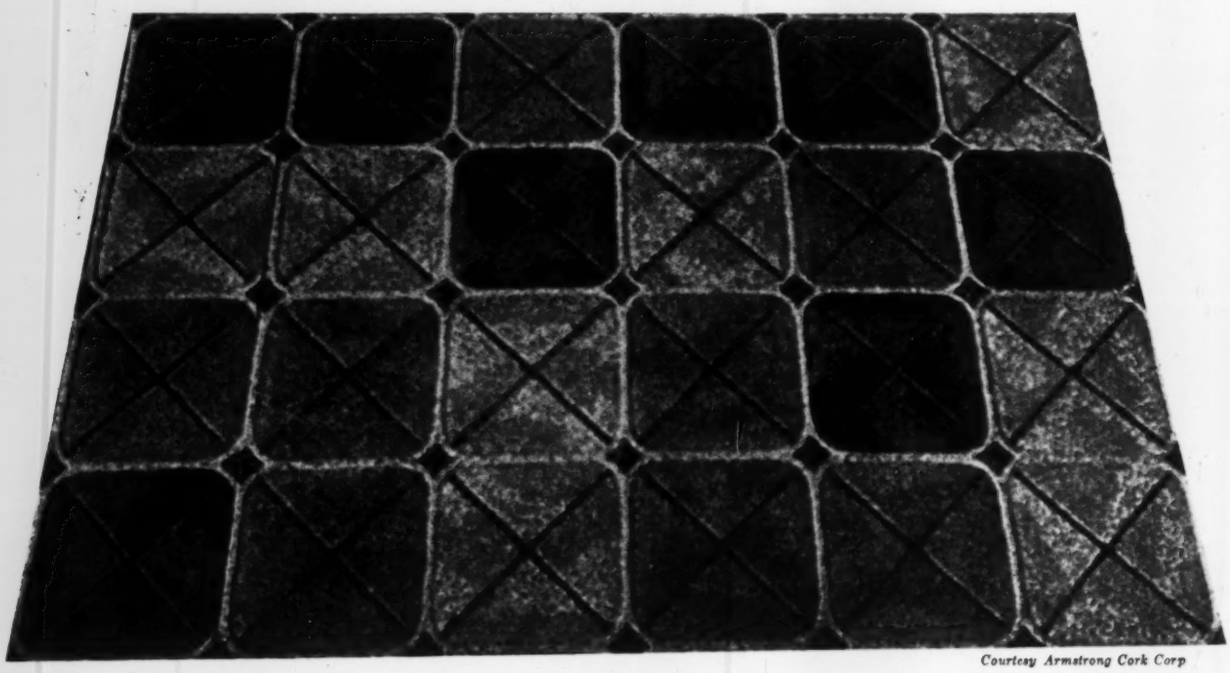


Courtesy Armstrong Cork Corp

MECHANIZATION *in* INDUSTRY

By B. A. THRESHER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEW SUBJECTS are more frequently alluded to in current economic discussion than the far-reaching effects of mechanization upon the social process. Perhaps none (except money) has yielded so numerous a progeny of rash conclusions and ill-considered proposals. One reason for this is the fact that the process of mechanization constitutes an important focal point in the complex of economic forces. Here influences from widely separated sources converge and strike a balance. Inventive progress constantly disturbs established relationships of costs, prices, wages and interest rates, employment, and earnings. In the immediate process of readjustment, labor suffers from displacement of jobs and special skills; capital suffers from obsolescence. The more remote readjustments of higher earnings and higher real wages are often made slowly and at unequal speeds. Though the long-run result has been constructive, the gains and losses are unevenly distributed and fall unequally on different groups. If technics may be said to reshape the social order, mechanization forms, so to speak, the cutting edge of the tool.

A STATISTICAL SURVEY OF MECHANIZATION

Previous studies in this area of economics have been essentially fragmentary. For this reason, Dr. Jerome's[1] recent book on mechanization is something of a landmark. Based upon a statistical survey covering a wide sample of industry, it provides an analysis and appraisal of a phenomenon which every engineer knows in its details, but which few engineers have occasion to view in full perspective. The survey covered 1300 plants in both manufacturing and non-manufacturing industries, utilizing field inspections, interviews, mail surveys, and supplementary study of technical and trade journals and other sources likely to shed light on the adoption of technical innovations. While the sample is wide by comparison with other studies, it comprises but a small fraction of the entire number of plants. It is made roughly representative, however, by deliberate inclusion of advancing and declining industries, as well as light and heavy, seasonal and non-seasonal, mechanical and manual industries.

We may relate Dr. Jerome's book to the general literature of the subject by first noting briefly what it is not. It does not, of course, purport to deal with all the economic problems involved in mechanization. It does not consider abstractly the long-run equilibrium adjustments of costs and prices consequent upon the adoption of labor-saving devices as was done by Paul Douglas and Aaron Director in "The Problem of Unemployment." It is not limited to an intensive study of a single process or industry as is Elizabeth Baker's "Displacement of Men by Machines" (confined to the printing industry) or the excellent studies of mechanization and labor displacement in certain industries published by the United States Bureau of Labor Statistics. Nor does it deal with the absorption of displaced labor into new jobs as do the special studies of Isador Lubin, R. J. Myers, and Ewan Clague. Finally, it does not advocate positive measures of control or remedies for the socially undesirable incidents of the mechanization process.

Dr. Jerome shows an appreciation of the statistician's responsibility not merely to collect and present figures but to analyze and interpret them. In so doing he has developed a number of analytical tools which refine the gross concepts current in popular discussion. He distinguishes "labor-saving" changes from "productivity-increasing" changes. These come to the same thing in the long run, but their immediate effects may be quite different. The extent of the net saving of labor, moreover, depends upon whether operating labor only is considered, or whether auxiliary labor, embodied labor (that is, labor embodied in the machine itself), or total distribution and marketing labor is included in the comparison. Over a long period, the net increase in the physical productivity of labor in the factory has been, in fact, partly nullified by the growth of distribution expense necessary to secure larger markets. This appears not merely in the manufacturer's selling costs, but in the whole structure of jobbing and distributing enterprises interposed between manufacturer and consumer. Thus in the decade 1920–1930 the percentage of the gainfully occupied attached to manufacturing dropped from 30.8 to 28.9, while the growth of those engaged in "trade" was from 10.2 to 12.5 per cent. This was associated with an estimated increase in output, per worker, of 43 per cent for the decade.

The displacement effected by labor-saving devices, furthermore, takes place at different levels. "If ... new brick-molding machines are introduced which, because of greater speed and more automatic features, make it possible for the machines with five operators to turn out the product formerly requiring ten operators ... then there is an 'operation displacement' of five men.... If these five men are not assigned other work in the same plant there is 'plant labor displacement.' If they find work in the same plant or in other plants, but in an occupation other than that of operating brick machines there is 'occupational displacement.' If they find work, but in an industry other than brick manufacture, there is 'industrial displacement.' If they find no work at all there is 'complete displacement.' "

WIDESPREAD EFFECTS OF OPERATION DISPLACEMENT

Dr. Jerome's summary, however, does not exhaust the possible cases, because it all starts with an "operation displacement" within a continuing enterprise. It may happen, however, that the adoption of improved methods by other enterprises in the industry displaces the entire firm employing the men in question. In more extreme cases, the entire industry may be undercut by economies introduced in the manufacture of substitute products. Such situations are more complex and difficult to analyze clearly, first, because the displacement from actual jobs extends to occupations not directly concerned in the mechanizing step which sets the sequence in motion, and second, because the elimination of an enterprise or industry is seldom due to a single clear-cut cause such as the mechanization of an operation. Shifts in markets, in consumer preference, geographical cost differentials, and similar complicating factors usually contribute to the result.

The most significant aspect of this study relates, however, not to the effects of mechanization (of which labor displacement is only one) but to its causes and the problem of measurement. Mechanization is a phenomenon of infinite diversity. Its manifestations over the whole field of industry have little in

[1] "Mechanization in Industry," by Harry Jerome, National Bureau of Economic Research, New York, N. Y., 1934. Cloth 6 × 9 in., 484 pp., 55 tables, 5 charts, $3.50.

common that is measurable. This is a prospect calculated to dismay the statistician, whose technique is best adapted to the comparison of homogeneous quantities. Dr. Jerome has sensibly refrained from stretching statistics too far. He briefly sketches the major qualitative changes in individual industries, with statistical series applying to restricted areas. But it is

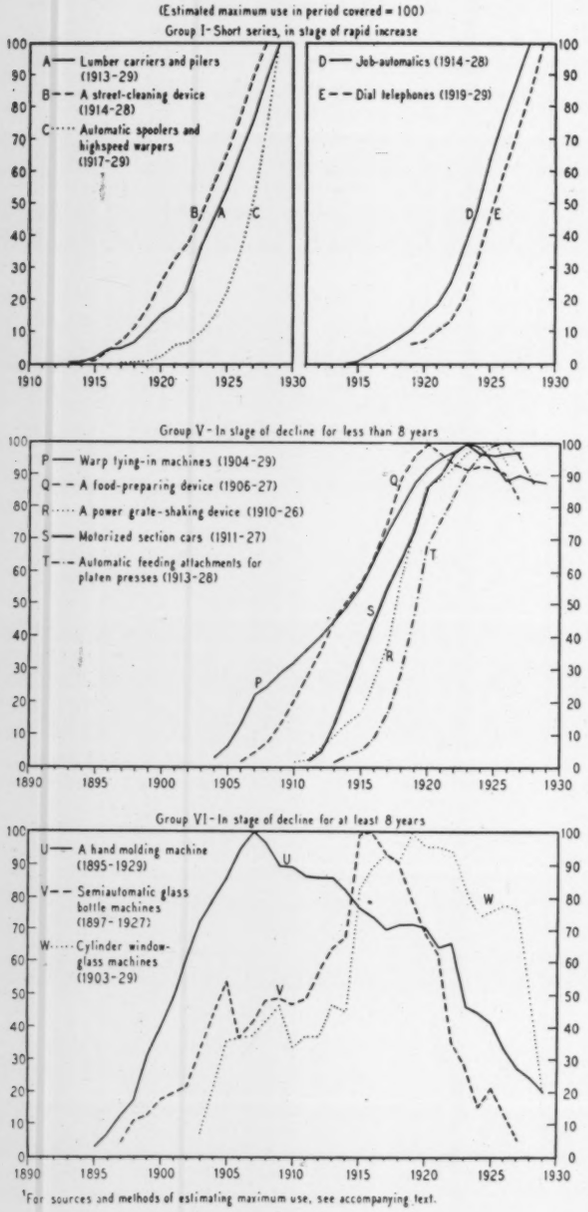

(Estimated maximum use in period covered = 100)
Group I - Short series, in stage of rapid increase
A — Lumber carriers and pilers (1913-29)
B - - A street-cleaning device (1914-28)
C ····· Automatic spoolers and highspeed warpers (1917-29)
D — Job-automatics (1914-28)
E - - Dial telephones (1919-29)
Group V - In stage of decline for less than 8 years
P — Warp tying-in machines (1904-29)
Q - - A food-preparing device (1906-27)
R ····· A power grate-shaking device (1910-26)
S — Motorized section cars (1911-27)
T - · - Automatic feeding attachments for platen presses (1913-28)
Group VI - In stage of decline for at least 8 years
U — A hand molding machine (1895-1929)
V - - Semiautomatic glass bottle machines (1897-1927)
W ····· Cylinder window-glass machines (1903-29)
[1]For sources and methods of estimating maximum use, see accompanying text.

FIG. 1 GROWTH IN THE USE OF MACHINES
(Reproduced from "Mechanization in Industry," by permission of the publishers.)

difficult to merge into one coherent picture figures relating to the adoption of machine types in such diverse fields as, for example, printing, glass making, motion pictures, and agriculture.

This fact necessitates recourse to a few available time series which, while not measuring mechanization directly, serve as indexes of related tendencies. Among these are (1) horsepower (rated capacity) per wage earner, (2) ratio of wages to value added in manufacture, (3) labor-expense ratios (e.g., ratio of wages to value added by manufacture, (4) percentage of total output due to machines (available in industries where machine adoption has partially displaced hand methods), and (5) dollar investment in equipment per wage earner.

Horsepower statistics[2] have, of course, been extensively used and their shortcomings are well-known, but such figures, as well as those relating wages to value have the advantage of being readily available from census figures. Others, such as labor-expense ratios and percentage of total output due to machines, must be obtained by study of individual plants. In horsepower per wage earner (as of 1925) blast furnaces lead with a figure of 47.29, followed by manufactured ice (31.41) and cement (18.31). At the bottom of the list are women's clothing (0.19) and turpentine and rosin (0.10). Obvious technical differences among industries render data of this kind of limited value as absolute magnitudes. Studies of rates of change have more significance, but a wide field for further investigation exists for working out measures which shall be comparable among different industries for such elements as relative degree of automaticity, transfer of skill, and displacement of occupational specialties. It is an area in which more refined qualitative study should precede efforts at measurement.

CHARACTERISTICS OF GROWTH

The factors determining rapidity of mechanization are grouped by Jerome into three classes roughly distinguished as technical, pecuniary, and psychological. He makes a pioneer effort to study this aspect quantitatively by assembling 23 series exhibiting life histories of machine types for periods ranging from 11 to 23 years. His conclusion is that the following stages are roughly typical: (1) Period of commercial trial (until use reaches 10 per cent of maximum) lasting 3 to 11 years; (2) period of rapid increase (ending when annual increase in use falls below 10 per cent) lasting 4 to 11 years; (3) period of slackened increase lasting 3 to 6 years; (4) period of declining use for which no typical duration is distinguishable. Three of Dr. Jerome's charts, reproduced herewith, illustrate series in different stages of this progress. These show admirably the complexity of mechanization as an economic factor. The process is one of continual displacement of existing types, not merely a progressive growth.

These series relate also to a social aspect of mechanization beyond the scope of this study, but which is suggestively treated in Lewis Mumford's "Technics and Civilization." The ultimate criterion of any technical process is not the horsepower consumed nor even the intricacy of the technical devices, but rather the question of how directly and cheaply the process serves the end sought. It follows that technical progress in some cases may bring about a decrease in power consumption, or in the use of certain machine types. Mechanization, in other words, is only a single aspect of technical change.

Among the broad conclusions reached by Jerome are these: (1) That while the rate of mechanization clearly reached a peak in the decade of the twenties, this rate was more rapid in agriculture, mining, and railroads than in manufacturing; (2) that while mechanization may be expected to continue, it will not be at the uncontrollable rate which some alarmists have pictured. The spectacular shifts that follow sudden innovations (like sound movies) which displaced, almost overnight, thousands of musicians, are far from typical. The process, viewed as a whole, is a steady one in which revolutionary upsets in particular technical operations appear only as ripples in the tide.

[2] See, for example, "Horsepower Equipment in U. S.," by C. R. Daugherty, *American Economic Review*, September, 1933.

SOLID SMOKELESS FUEL

Its Production by Carbonization of Utah and Wyoming Coals

By S. CLARK JACOBSEN and GEORGE W. CARTER

SALT LAKE CITY, UTAH

WHEN raw coal is heated in the absence of air to prevent combustion, the process performed is known as the carbonization or destructive distillation of coal. The terms "high-temperature" carbonization and "low-temperature" carbonization are used to describe the two broad classes of coal treatment that have been most extensively applied thus far.

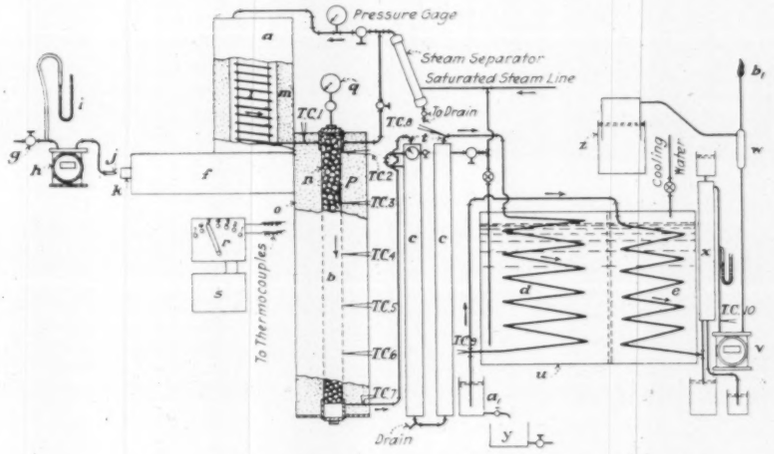


FIG. 1 LAYOUT OF EXPERIMENTAL PLANT

High-temperature carbonization is carried on at temperatures ranging from 900 to 1200 C (1650 to 2190 F) and the resulting coke is primarily intended for industrial uses. It contains little volatile material and is of a graphitic type which makes it difficult to ignite.

Low-temperature carbonization is effected at relatively low temperatures, which may range from 360 to 750 C (680 to 1380 F). The fundamental reason for use of lower temperatures is to prevent secondary decomposition of the distilled vapors, so that the vaporized constituents of the coal will have certain valuable characteristics not found in the products of high-temperature distillation. Also the carbon residue, known as semi-coke, is not graphitic and ignites and burns more readily than the high-temperature cokes.

We know that the element of time is important in the amount of cracking taking place at any given temperature. Consequently, the authors believe that low-temperature carbonization should be defined necessarily as a "condition" and not as a "temperature range" of destructive distillation, wherein a minimum of secondary decomposition of the oil vapors takes place, a relatively low yield of high Btu gas is evolved, and the residue or semi-coke is an easily combustible form of carbon.

Although much time has been given to a study of Utah coals as the source material for a smokeless fuel, but little experimental work has been done and no paper has treated this subject in detail. That is, the three products of destructive distillation, solid smokeless fuel, crude oil, and artificial gas, have not been studied in detail in relation to their production from the principal coal bodies of the Intermountain Region.

The authors undertook, therefore, to make a study of the important high-volatile smoke-producing coals so extensively laid down in Utah and Wyoming in order to determine their suitability as source materials for solid smokeless fuels. The investigation was carried on during 1934 under the direction of Professor Beckstrand of the Department of Mechanical Engineering at the University of Utah, and the process employed was that of Mr. Karrick[1] who, after many years of intensive and thorough research in the laboratories of the United States Bureau of Mines, formulated a number of methods for treating these Western coals. Consequently, this investigation was a continuation of and was aided by the extensive engineering and economic studies of Western coals made by the Federal Government in cooperation with the State of Utah.

OBJECT OF INVESTIGATION

The object of the investigation was to obtain detailed data on the following items as they pertain to the bituminous and sub-bituminous Utah coals:

(1) Adaptability of the coals to the distillation process.
(2) Heat required, steam consumption, and time necessary to distil the coal, and the mechanism of the heat transfer.
(3) Yields of solid smokeless fuel, crude oil, and artificial gas.
(4) Physical and chemical properties of the smokeless fuel versus the raw coal.
(5) Heating efficiency of the smokeless fuel versus the raw coal in ordinary coal-burning appliances.
(6) Constituents and heating value of the artificial gas.
(7) Life of the materials used in the construction of the superheater and retort.
(8) Quantity and quality of the products obtainable from the crude oil.

EXPERIMENTAL CARBONIZING PLANT

For the purpose of carrying out this investigation, a small carbonizing plant capable of yielding commercial coal products, was erected in the Mechanical Engineering Laboratories of the University of Utah. The coal was treated in batches of approximately 50 lb each by means of superheated steam at approximately 10 lb pressure and at temperatures ranging from 1000 to 1350 F, and in direct contact with the coal charge.

The major parts of the plant as shown diagrammatically in

[1] L. C. Karrick, Former U. S. Government Refinery Engineer and Fuels Technologist.

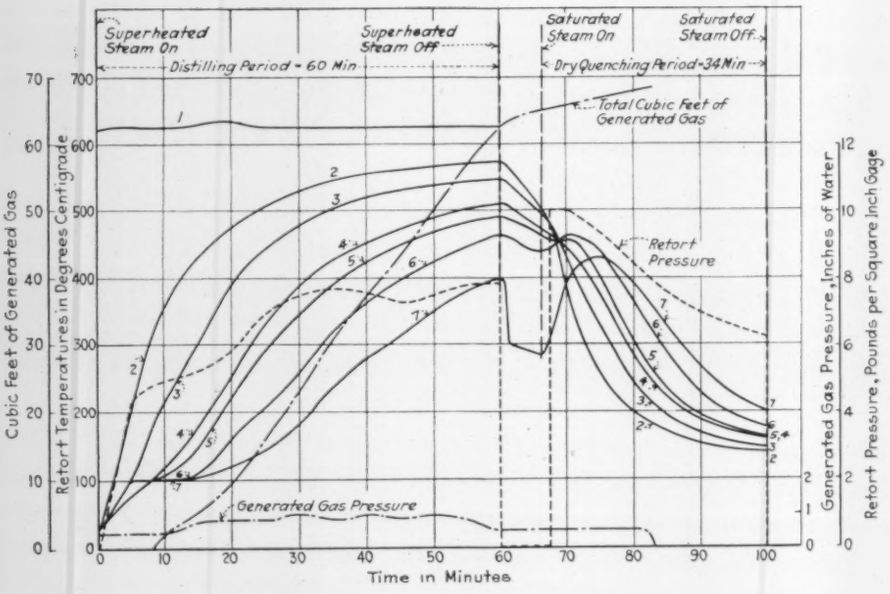

Superheated Steam On
Superheated Steam Off
Saturated Steam On
Saturated Steam Off
Distilling Period = 60 Min
Dry Quenching Period = 34 Min
Total Cubic Feet of Generated Gas
Retort Pressure
Generated Gas Pressure
Cubic Feet of Generated Gas
Retort Temperatures in Degrees Centigrade
Generated Gas Pressure, Inches of Water
Retort Pressure, Pounds per Square Inch Gage
Time in Minutes

FIG. 2 LOG OF PLANT OPERATION
(Detailed test No. 2—Aberdeen pea coal.)

Fig. 1 consisted of the superheater *a*, the coal retort *b*, the three condensers, *c*, *d*, and *e*, the condensate decanter a_1, the condensate measuring tank *y*, the gas scrubber *x*, the gas meter *v*, the gas sample storage tank *z*, and a potentiometer and thermocouples. The positions of the latter are indicated by the letters *T. C.*

Heat was supplied to the superheater by a gas-fired furnace *f* arranged so as to permit the careful regulation of the quantity of heat generated.

The steam condenser *c* provided a means of condensing out of the vapor stream only the high-boiling oil vapors while preventing any condensation of water vapor. By thus removing the high-boiling oils, which were found to be slightly heavier than water, the remaining oils and water could be condensed together in another condenser and thereafter separated by decantation. Without such selective condensation, the crude oil could not have been separated easily from the water. A thermocouple was provided at the vapor outlet of this condenser.

Condensers *d* and *e* consisted of two coils placed in series and occupying separate compartments in the condenser box *u*. Cooling water flowed in a direction counter to the vapors being cooled, the condensate from condenser *d* being maintained above 70 F to prevent the condensed waxy oils from congealing and clogging the coils. A thermocouple was provided at the outlet of this condenser for the purpose of observing this temperature. The oil and water condensates from condenser *d* were drawn off under a liquid seal into the decanter a_1, which was provided with an oil overflow pipe, while the water settled to the bottom and was permitted to drain into the tank *y* fitted with a water-level tube calibrated in pounds. The remaining vapors and gases from condenser *d* were passed into condenser *e* surrounded by cold water. In this the light oils were condensed and collected in a liquid-sealed container.

The non-condensable gases were then passed up through the scrubbing tower *x* to remove the naphtha fog carried in the gases. The tower was filled with sized gravel over which absorption oil trickled in counterflow direction to the gases. The used oil was drained from the base of the tower and topped to collect the naphtha. The naphtha-free gases were then passed through meter *v* provided with a thermocouple and a manometer, and thence through the sampling tube *w* to the torch b_1 where they were burned. About one-hundredth part of the gases were diverted by the sampling tube into the gas holder *z*.

CLASSIFICATION OF TESTS

The tests made were divided into "preliminary" and "detailed."

The purpose of making the preliminary tests was to secure sufficient data to indicate the adaptability of important coals to retorting by the process and also to provide information that would indicate the quantity and physical characteristics of the smokeless fuel, as well as the yields of crude oil and artificial gas. This information would then permit the selection of the coals that would later be studied in detail.

The detailed tests were made to determine (1) the effect of the distilling temperature upon the resulting products, (2) the heat requirements, (3) the amount of steam required, and (4) the mechanism of the heat transfer to the coals chosen on the basis of the preliminary tests.

PRELIMINARY TESTS

The steam supply to the superheater was maintained at such a rate as to produce a pressure on the retort of from 3 to 10 lb per sq in. gage or from 15 to 22 lb per sq in. gage at the superheater inlet. During the dry-quenching period the superheated steam was by-passed to the atmosphere and saturated steam at 15 lb pressure was passed through the retort. Table 1 gives the results of these preliminary tests and from this table it will be noted that the bituminous coals gave from 1230 to 1400 lb of smokeless fuel per ton of raw coal, from 2100 to 3200 cu ft of artificial gas having a heating value ranging from 800 to 1050 Btu per cu ft, and from 269 to 319 lb (32 to 38 gal) of dry crude oil per ton of coal. The sub-bituminous coals yielded smaller quantities of smokeless fuel and oil and gave larger quantities of artificial gas.

DETAILED TESTS

Three detailed tests were conducted on a typical bituminous coal and three on a sub-bituminous coal using superheated steam temperatures of 538, 650, and 725 C. The size of the coal lumps were within the range of 2-in. to $^3/_4$-in. and the readings of the instruments were made every 5 min. Fig. 2 shows graphically the record of such a test.

Distillation. As was to be expected, the length of the distilling period was inversely proportional to the temperature of the superheated steam used. The superheated-steam temperature did not, however, have any considerable effect upon the length of the dry-quenching period. In all the detail tests the temperature of the lower zone of the retort, indicated by thermocouples 4, 5, 6, and 7 (Fig. 1), did not begin to rise above 100 C for some 15 or 20 min after the distillation was begun. This temperature lag is produced by the presence of water in the coal. As soon, however, as the moisture is driven out of the coal, the temperature rises rapidly, the rate of rise being aided by the exothermic property of Utah coals.

It has been shown that this exothermic heat amounts to 27

to 45 Btu per lb of coal and with the method used in this study the exothmeric or internal heat is utilized within the distilling range of temperature to augment the useful (distilling) heat of the superheated steam. A study of Fig. 2 will show how the temperature curves cross each other during the dry-quenching period because of the heat exchange taking place in the coal charge. Also, it will be observed that the temperatures increase for a while in the lower part of the coal mass during the dry-quenching operation. The transfer of this "high-temperature" heat in the upper part of the coal charge to the lower part of the charge, whereby it accomplishes useful work, is a unique feature of this method of treating coal, and it serves to reduce the amount of superheated steam required. It may be concluded that this heat-saving step will be greatly enhanced in distilling large batches of coal in large-diameter retorts wherein the retort surface (the radiating area) is a much smaller heat-dissipating factor than in the retort used in the present study. Also in larger batches of coal the available heat stored in the residue is a much larger percentage of the total heat required.

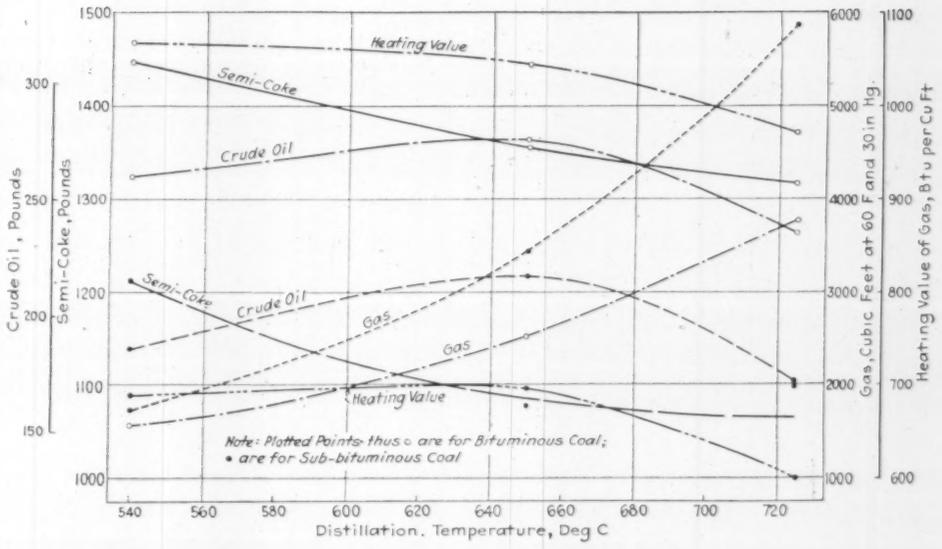


FIG. 3 YIELDS OF LOW-TEMPERATURE CARBONIZATION PRODUCTS FROM ONE TON OF UTAH BITUMINOUS AND SUB-BITUMINOUS COALS

Fig. 3 shows the effect of the distilling temperature upon the yields of smokeless fuel, oil, and gas, and also the heating value of the gas.

In each instance, the yield of semi-coke decreased while the gas yield increased with increase in the distilling temperature. The heating value of the gas, however, decreased with the greater gas yields. The oil yield was a maximum at 650 C and was a smaller value at 730 C than at 540 C. It is interesting to note the striking similarity in the trends of the curves for the bituminous and sub-bituminous coals, which clearly indicate that, for optimum results, 650 C is the better distilling temperature.

The heat balance shows that 75 to 80 per cent of the heat supplied leaves the retort in the steam and volatiles. Important economies in steam consumption can be obtained (1) by preheating the coal, (2) by using maximum steam temperature consistent with the optimum character and yield of the products (650 C), (3) by using physically dry coal, (4) by utilizing the heat stored in the top portion of the coal charge to distil by transfer of its heat to the lower portion of the coal charge, (5) by reducing the heat absorption in the walls of the retort by using a retort covering of low conductivity and heat capacity, (6) by reducing radiation losses, (7) by using the sensible heat of the coal residue to preheat the new coal, (8) by condensing the issuing steam and oil vapors in an evaporator and using the new steam generated to dry-quench and preheat other new coal charges. There are good evidences that with the use of three or more retorts as a unit, the distilling, preheating, and dry-quenching can be carried on simultaneously, thereby effecting distinct heat economies.

TABLE 1 RESULTS OF PRELIMINARY TESTS

Coal	Pounds smokeless fuel per ton coal	Cu ft gas per ton coal at test conditions	Pounds crude oil per ton coal	Gas analysis—per cent by volume at 60 F and 30 in. Hg						
				CO_2	Ill.	CO	H_2	CH_4	C_2H_6	Btu per cu ft
Sub-Bituminous										
Grass Creek	1106	3100	204	26.0	7.6	15.5	9.4	32.7	9.4	805
Weber	1130	3350	201	....	....	....	....	....	....	...
Weber	1200	3135	186	....	....	....	....	....	....	...
Lazert	1133	3380	138	33.8	4.2	15.5	13.1	29.6	3.5	578
Bituminous										
Castle Gate No. 2 Mine—"D" Seam	1400	2630	239	....	....	....	....	....	....	...
Castle Gate No. 3 Mine—"F" Seam	1361	2540	253	....	....	....	....	....	....	...
Clearcreek	1326	2660	249	....	....	....	....	....	....	...
King	1308	2475	285	14.9	9.2	9.7	16.7	40.0	7.7	901
King	1277	2185	286	....	....	....	....	....	....	...
Aberdeen	1358	3260	283	....	....	....	....	....	....	...
Aberdeen	....	2885	259	....	....	....	....	....	....	...
Standard	1370	2690	275	15.8	14.6	11.3	5.7	52.8	....	1018
Sevier Valley	1231	2760	275	18.3	8.4	10.7	16.8	36.0	9.6	876
Rilda Canyon	1277	2135	319	....	....	....	....	....	....	...
Rock Springs	1288	2540	221	....	....	....	....	....	....	...
Kemmerer—Susie	1420	2700	202	13.2	9.5	8.4	19.8	41.5	8.7	951
Kemmerer—Susie	1366	2900	197	....	....	....	....	....	....	...
Sevier Valley	1300	3110	269	19.0	7.75	10.9	21.6	35.3	5.43	789

Table 2 gives the proximate analyses of the raw bituminous and sub-bituminous coals and the corresponding treated product or smokeless fuel obtained during the detailed tests conducted at 650 C.

Characteristics of By-Product Oil. Analyses of the crude oils from the different coals treated in this study proved them to be quite

TABLE 2 PROXIMATE ANALYSES OF BITUMINOUS AND SUB-BITUMINOUS COALS AND THEIR RESULTING SMOKELESS FUELS

Content	Bituminous: Raw coal	Bituminous: Smokeless fuel	Sub-Bituminous: Raw coal	Sub-Bituminous: Smokeless fuel
	Per cent by weight			
Moisture	3.2	....	12.53	....
Volatile	39.7	17.5	35.8	30.5
Fixed carbon	50.8	74.1	47.83	62.0
Ash	6.3	8.4	3.84	7.5
Sulphur	0.53	0.45	1.5	1.0
	Btu per pound			
Heating value	13,300	13,000	10,850	13,248

similar. Consequently the crude oil from a representative Utah coal was used for an investigation of the refinability of this oil.

Gasoline was the principal oil product sought, although kerosene, fuel oil, fuel gas, and cresylic acid were also produced and their quantities measured. A 2-gal pressure cracking still was provided with a thermocouple well, pressure gage, a water-cooled pressure condenser, and a pressure-regulating needle valve. A charge of 1.5 gal of the crude oil was first dehydrated under pressure and then cracked at 775 to 800 F and 125 lb pressure, the distillation requiring about 3 hr to complete.

This crude oil is solid at room temperatures because of the high content of waxes, resins, and high-boiling hydrocarbons. The distillation yielded 65 per cent of pressure distillate, also carbon and gas. About 110 lb of carbon (ashless coke) and 850 cu ft of 1350-Btu gas were produced per barrel of the crude oil cracked. The pressure distillate was fractionated at 205 and 253 C at 640 mm pressure, thereby forming three fractions, gasoline, kerosene, and fuel oil. All fractions were washed with 10 per cent sodium-hydroxide solution to remove the tar acids which were subsequently released from solution by neutralizing with sulphuric acid. The gasoline was then agitated with concentrated sulphuric acid in three successive treatments, after which it was neutralized and distilled. This yielded 18 per cent of light yellow gasoline which was color-stable and of the proper volatility for motor use. The kerosene was similarly refined but with less acid.

The yields of the oil products were as recorded in Table 3.

TABLE 3 YIELDS OF OIL PRODUCTS

Product	Per cent of crude	Gal per ton of coal
Gasoline	18	5.85
Kerosene	18	5.85
Fuel oil	20	6.40
Cresylic acid	3.1	1.0

Ignition and Burning Qualities of Semi-Cokes. Throughout this investigation a large number of experiments were made to compare the ignitibility and burning properties of the semi-cokes produced with raw coal, metallurgical coke, petroleum coke, cannel coal, and anthracite.

This study was accomplished in part by placing equal-sized pieces of the different fuels into separate, electrically heated muffles in the presence of air and causing all to heat up simultaneously at controlled rates until combustion took place. It may be briefly stated that the semi-coke kindled as readily as raw coal and exhibited an attractive but smokeless flame, also that it did not disintegrate while burning as did the raw coal.

The metallurgical coke was the most difficult to ignite, the anthracite next, and while the petroleum or creosote cokes ignited fairly readily, both were observed to yield an oily smoke when starting to burn.

The unusual capacity of the semi-coke to ignite easily and burn readily was demonstrated in a series of tests made in standard house-heating devices. Burning tests were made on a hot-blast heating stove and a cook stove, which are typical of the types used to heat some twelve thousand small dwellings in Salt Lake City. A fireplace was also constructed and all three appliances were equipped with the necessary instruments to measure draft, flue-gas temperatures, smoke and fly-ash in the gases, and to take gas samples. A series of heating studies was made to compare the semi-coke with the raw coal and in all instances attempts were made to duplicate average residence firing technique. It was found that the semi-coke gave 15 per cent more heat than the raw coal in the heating and cook stoves and nearly three times as much heat as the raw coal in the fireplace. Furthermore, more than 100 times more soot, tar, carbon, and ash were collected from the flue gases arising from the raw coal. The semi-coke also responded readily to draft changes and produced no visible smoke.

CONCLUSIONS

The results of the investigations are summarized as follows:

(1) All of the bituminous coals tend to soften while processing in varying degrees but none has the extreme fusing properties for successful high-temperature coke manufacture.

(2) The greater portion of Western bituminous coals can be discharged easily from a slightly tapered retort.

(3) Practically all Rocky Mountain coals, exhibiting minor fusing characteristics, are well adapted to low-temperature carbonization in retorts. All sub-bituminous coals are likewise well adapted to this method of treatment.

(4) All of the crude oils derived from the coals processed had the same general physical characteristics as to color, viscosity, and density.

(5) From 85 to 90 per cent of the smokeless fuel produced from the bituminous coals was above $^3/_4$-in., which was the minimum size of the coal as originally charged. Consequently, very little breeze or fine carbonized coal was produced.

(6) The sub-bituminous coals were observed to disintegrate slightly upon processing, but it was found that this degradation could be materially reduced by a slower rate of heat transfer.

(7) Sub-bituminous coals from Coalville, Utah, gave a smokeless fuel which, according to proximate analysis, is practically the same as that produced from bituminous coals. In most cases, the ash content of the sub-bituminous semi-coke was less than that of the bituminous smokeless fuel.

(8) The new domestic fuel produced during the course of this investigation was well suited to burning in domestic coal-burning appliances. Many combustion studies were made in a popular form of hot-blast heater, in a cook stove and fireplace, and several sacks of the new fuel were distributed among interested local citizens for trial. In each case the fuel ignited easily and burned without any trace of smoke and only favorable comments were received from the many enthusiastic persons who saw this fuel in use. Proximate analyses of the semi-cokes show that their heating values are approximately equal to those of the raw coal, and that the ash content never reached 10 per cent. Furthermore, 15 per cent more heat is made available through the use of the processed coal than is obtained by the use of the same amount of the raw high-volatile coals.

(9) The experience gained during this investigation and a careful inspection of the apparatus after completion of the test gives assurance that no unusual difficulties would be met with these pieces of equipment in commercial practice.

(10) The studies show that with the use of three retorts as previously described, a pound of coal can be treated with less than one pound of superheated steam.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

APPLIED MECHANICS

Moments of Resistance and of Inertia of Circular and Circular-Ring Cross-Section

IN FIG. 1, $W_p = 0.2d^3$ for circular cross-sections and $W_p = 0.2\,\frac{D^4 - d^4}{D}$ for circular-ring cross-section. The values of W_p are read from the diagram and from this $W = 0.1\,d^3$ or $0.1\,\frac{D^4 - (D - 2s)^4}{D}$ can be obtained by multiplying the values of W_p by 0.5. The values of I are obtained by multiplying the values of W_p by $0.25\,D$.

The following example will show how to proceed in this case. Let it be desired to find W for a pipe 45 mm O.D. and 30 mm I.D. The wall thickness is therefore 7.5 mm. First find the point of intersection of the curve for the 45 mm O.D. with the vertical line of wall thickness located between 7 and 8 mm. This gives $W_p = 14.5$ cm³; and from this it will be found that W is $0.5 \times 14.5 = 7.25$ cm³.

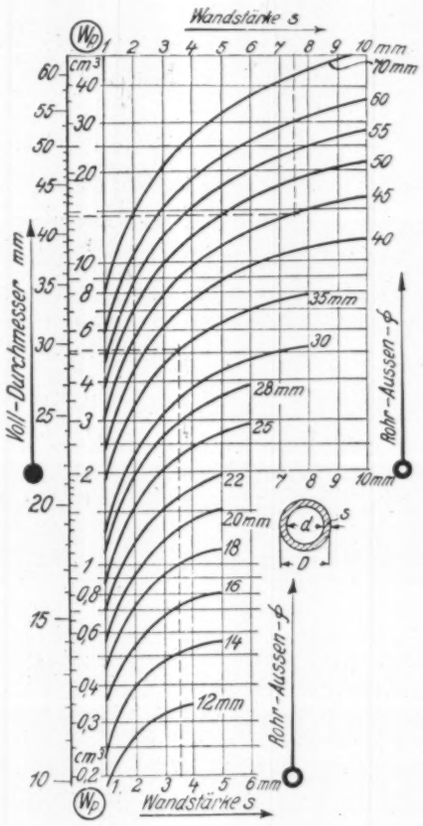


FIG. 1 RESISTANCE AND INERTIA MOMENTS OF CIRCULAR AND CIRCULAR-RING CROSS-SECTIONS

(Abscissas = wall thickness, s in mm; ordinates, left, total diameter in mm; ordinates, right, outside diameter of pipe in mm.)

If, however, it is desired to find the value of wall thickness for a pipe of a cross-section where $I = 4.5$ cm⁴ and 35 mm O.D., the following procedure is used. If $I = 4.5$ cm⁴, then $W_p = I/0.25\,D$, which can also be written $W_p = 4.5/(0.25 \times 3.5) = 5.15$ cm³. The curve for O.D. 35 mm intersects the horizontal line for $W_p = 5.15$ cm³ at about 3.5 mm, which gives the wall thickness of the desired pipe.

The next subject considered deals with the moments of resistance and inertia of I and U and rectangular cross-sections. This is not abstracted because of lack of space. (Design Tables, no. 1, 1935, *Automobiltechnische Zeitschrift*, vol. 38, no. 1, Jan. 10, 1935, 2 pp., insert opposite p. 20 of the general issue)

ENGINEERING MATERIALS

Progress in Metals Used in Steam Engineering

AMONG other things the author refers to some special vanadium steels which proved highly successful for such applications as piston rods and crankpins. He mentions specifically the manganese-vanadium steels containing approximately 1.4 per cent manganese, 0.10 vanadium, and 0.35 per cent carbon. It has been recently found that steels with 1 per cent of copper combined with approximately ½ per cent molybdenum are much better as regards corrosion resistance than ordinary mild steels and possess fair strength at moderate temperatures.

In attempts to find a suitable steel for resistance to corrosion attack at high temperatures, steam engineers have turned back of late to the original 12 to 14 per cent chromium stainless steel. Seamless tubes for high-pressure steam boilers have made use of this material while steel higher in chromium, namely of the 20 per cent chromium type, has been employed in tube form for waste-heat recuperators, soot blowers, and high-temperature superheaters.

The matter of aging of steel sheets is considered next. The method which gives promise of success is to deoxidize the steel with silico-manganese in the furnace and kill with aluminum in the ladle.

The nitriding process has not gone ahead quite so rapidly as at one time seemed likely. Recent progress consists in the invention of a method of nitriding ordinary steels, and one or two of the cast and malleable irons, to a glass-hard surface. Two patented modifications of the nitriding process have been introduced. In the first of these, ordinary steels low in carbon content are subjected to active nitrogen led into a salt bath and then quenched; in the second, molybdenum, chromium, or chrome-vanadium steels are subjected to activated nitrogen at low temperature in a pressure-tight container, thus obtaining swiftly a very hard case without the necessity of quenching. It may be mentioned also that experiments seem to prove that castings with 20 per cent and more of chromium when alloyed with nitrogen are higher in resistance to corrosion and in ductility than steels without nitrogen. (L. Sanderson in *The Steam Engineer*, vol. 4, no. 6, March, 1935, pp. 231–232)

Notch Sensitiveness in Alternating Stressing of Alloyed and Unalloyed Steels

IN CONNECTION with long-duration tests of steels in recent years several statements have been made to the effect that alloyed steels have a higher notch sensitiveness than unalloyed steels. The author claims that these statements are based on an insufficient amount of experimental work or else that they are based on comparisons of steels of different tensile strength and elastic limit. It is an important matter for designers to know whether or not there is an actual difference in the notch sensitiveness in alternating stressing of alloyed and unalloyed steels.

With this in view the experimental laboratories of Friedrich Krupp Co., Essen, have carried out certain tests on test pieces 7.5 mm in diameter of various surface characteristics, namely: (*a*)

Smooth bar with a surface carefully polished; (*b*) smooth bar with the surface finely ground; (*c*) smooth bar with the surface coarsely machined; (*d*) bar with a notch 0.1 mm deep and 60-deg angle, with the bottom of the notch as sharp as possible; and (*e*) bar with a groove about 1 mm in diameter. These test pieces were subjected to long-duration bending tests. It is only in a few cases that all of the bar shapes were tested in any given steel. In the majority of cases only type (*a*) and one or two others were tested. The data of the tests and the methods of computing the results are given in the original article.

The test bars may be divided into five groups according to their chemical compositions, namely, unalloyed, manganese and silicon, nickel, chromium, and chrome-nickel steels. A sixth group consisted of austenitic steels. The results of tests of alternating strength of polished and notched pieces were plotted as functions of tensile strength. Because of the lack of space the details cannot be reported here, but some of the conclusions are presented. Among other things it was found that on the basis of equal tensile strength the unalloyed steels are inferior to the other steels in the absolute magnitude of long-duration test strength, for both polished and notched pieces. From the data presented, however, one cannot draw a very clear idea of the difference in notch sensitiveness, as the alternating strength of a steel with a polished surface may lie at the upper limit of values, while a similar strength for a notched test piece may be at the lower limit of values. For another steel an entirely different situation may be found.

When it was tried to plot the various alternating-strength data as functions of tensile strength it was found that the points were so scattered that it was not always possible to draw an average curve. The general conclusion which the author draws is that it does not appear that unalloyed steels are any less notch-sensitive than alloyed steels of the same tensile strength.

The values for alternating strength in the case of notched test pieces have been also plotted as a function of the corresponding alternating strength of polished pieces. Here, as in some other tests, it has been found that austenitic steels are clearly less notch-sensitive than others. It was also found that when test pieces which in the polished state showed equal alternating strength were compared in the notched state, unalloyed steels not only did not show a higher alternating strength but at times showed a somewhat lower one than alloyed steels.

In connection with the estimation of the coefficients of notch sensitivity of various steels it should be noted that this property depends on the purity of the material. A material with strong internal notch effects shows a lower notch sensitivity because its strength is impaired by these internal notch effects.

In general conclusion, however, the author states that the notch sensitiveness of a steel is essentially a function of its tensile strength. When endowed with equal elastic limits the unalloyed steels have approximately the same notch sensitivity as alloy steels, excepting, however, austenitic steels. (Richard Mailänder, communication no. 291 of the Materials Bureau of the Association of German Steel Manufacturers, abstracted through *Stahl und Eisen*, vol. 55, no. 2, Jan. 10, 1935, pp. 39–41, 5 figs.)

INTERNAL-COMBUSTION ENGINEERING

Detonation and Pseudo-Detonation in Explosion Motors

THE author has read several papers before the French Academy of Sciences on the subject of detonation and says now that such expressions as "detonation," "knocking," and "pinking" are used indiscriminately to describe the phenomenon of extremely rapid increase of pressure expressing itself in a sharp metallic noise, a considerable increase in the heating of the cylinder walls, and a reduction in the amount of power developed.

The author claims that his theory of nuclear ignition makes it possible to expect a different phenomenon in a motor, marked, at some hot point or in a region of high temperatures, by the appearance of a "flame front" without the formation of a detonation wave. He believes he has confirmed it experimentally.

In tests on superinduction with a motor having adjustable cooling temperatures it was found that when the temperature of the water was of the order of 80 C and the spark was progressively advanced the appearance of knocking was preceded by irregular operation accompanied by a dull noise entirely different from that of pinking, properly so-called. On the other hand when the temperature of the water was only from 40 to 50 C there was a direct passage from silent operation to operation with knocking. Diagrams were taken for these different cases on a manograph of small inertia. It was found that in the case where there was intermediate knocking between regular operation and pinking there was a rapid increase of pressure at the end of the combustion lasting about 0.0005 sec, followed by pressure waves, the frequency of which materially corresponded to the tonality of the noise heard. This did not appear at more moderate loads and temperatures of the walls. On the other hand, when the motor was dismantled it was found that a casting defect affecting the circulation of the water had produced a hot spot in that part of the wall.

It would therefore appear that all the elements are present justifying the statement that the phenomenon observed is due to ignition by a hot spot acting a little before the end of the combustion and accompanied by considerable acceleration of the rise of pressure without producing a detonation wave, properly so-called. This last point seems to be sufficiently corroborated by the fact that neither a reduction in power developed nor any abnormal heating of the motor was found. From this it would seem that the appearance of knocking, properly so-called, may be preceded on certain motors and under certain conditions by ignition by a hot spot. This is expressed in a noise much less pronounced than pinking and is not accompanied either by loss of power or violent heating, such as accompanies regular detonation. This the author calls "pseudo-detonation."

Since it is the temperature that produces ignition that gives rise to detonation or pseudo-detonation and since both depend on the detonating properties of the fuel, this latter can be equally well measured on the basis of detonation, properly so-called, and on pseudo-detonation.

The author believes that he has found a confirmation of this detonation in the fact that the majority of the devices intended to uncover knocking, such as the bouncing pin used for the determination of the octane number, seem, because of their comparatively high inertia, more sensitive to pseudo-detonation than to true detonation. It would appear in fact that certain motors, such as the S.30 motor of the Ethyl Gasoline Corporation, which seem to have a high aptitude for producing pseudo-detonation, measure more frequently the intensity of the latter than the intensity of detonation, properly so-called. This does not, however, affect the results of measurements when used for classifying fuels.

In conclusion the author states that in so far as operation of engines is concerned

it is only detonation proper that must be avoided because of its harmful effects, and on that account the apparatus for measuring it should be of very small inertia, as such apparatus is not affected by pseudo-detonation. This has led the author to consider using a device responsive to the second root of the pressure as a function of time as this varies greatly with the duration of the shock. An apparatus based on this principle and having its own period of approximately $^1/_{30,000}$ sec, very sensitive to detonation, has been found to be effectively non-sensitive to pseudo-detonation. (Max Serruys, *Comptes Rendus des Séances de l'Académie des Sciences*, vol. 199, no. 18, Oct. 29, 1934, pp. 830–833)

Internal-Combustion Turbine

THE author believes that the combustion turbine once deemed economically impracticable deserves new consideration in the light of today's higher efficiencies of turbines and compressors and the ability of modern turbine blades to withstand high temperatures. He analyzes the constant volume and constant-pressure cycles and believes that the latter is apt to give the most satisfactory solution of the problem of the combustion turbine. He gives in detail the cycle of the proposed turbine and points out the conditions, particularly those dealing with combustion temperature and turbine and compressor efficiency, which must be satisfied in order that the turbine should develop more power than is required to drive the compressor.

The principal parts of the proposed turbine are the compressor and the turbine proper, preferably direct coupled. The compressor is of the multi-stage centrifugal type, in the design of which attention should be directed only to obtaining a maximum efficiency at the operating point and not to flat pressure characteristic. The most critical part is the turbine wheel, as it has to operate at the highest possible temperature, maintain high peripheral velocity, and be of a design consistent with high efficiency. A radial reaction wheel is recommended to be surrounded by a volute-shaped nozzle of double-wall construction with the inner wall insulated from the outer which, being cooler, relieves the inner one from pressure stresses.

The matters of air preheater and burner are next discussed, particularly what are claimed to be novel features of the latter. Operation of the burner differs from that of usual ones in that the pressure is above atmospheric which requires special provision for ignition.

To regulate the unit for a varying demand of power at constant speed it is necessary to use a temporary quick-acting element superimposed on a slow permanent change. Details of this will be found in the original article. The machine does not appear to have been built. As future improvements, are suggested overexpansion at the turbine wheel to reduce the temperature of the gases passing through the blade channels, possibly together with a higher combustion temperature than this would permit. (Wm. E. Trumpler, *Power*, vol. 79, no. 2, February, 1935, pp. 78–80, 3 figs.)

Small Diesel Engine

THERE is a growing conviction among engineers that one of the immediate goals of Diesel engineering lies in the development of the minimum-size motor. The small Diesel motor is not new in itself, but until recently the small motors had comparatively large cylinders and low speeds, which meant that their volumetric efficiency was very low. The small Diesel which Diesel himself presented in 1902 to the Technical High School of Munich had an output of 8 hp, cylinder bore 165 mm, stroke 270 mm, and ran at 270 rpm for a piston-swept volume of 5.77 liters and the low output of 1.39 hp per liter of volume.

The single-cylinder air-injection 50-hp motor built in 1920 ran at 216 rpm, and with a bore of 325 mm and stroke of 510 mm showed a piston-swept volume of 42.35 liters and output of 1.19 hp per liter. Very great changes have taken place since then, and of late motors have been developed with extremely small cylinder dimensions. Thus, for example, the Lanova Company, of Munich, has built a single-cylinder motor with a bore of 60 mm, stroke of 100 mm, and piston-swept volume of 0.28 liter, as well as a six-cylinder engine with bore of 58 mm and stroke 94 mm, the latter running at 3600 rpm. It was not easy to create a Diesel engine with such small cylinders either for speeds of 500 to 1000 rpm for stationary units or for motor-vehicle drive with speeds up to 3000 rpm. First of all suitable pumps and nozzles had to be developed, and the solution of this problem has certainly not been assisted by the passage within the last few years from air injection of fuel to airless injection. It was further necessary to establish that the jet-injection method which showed up so well in large engines did not work out as well in small engines of the fore-chamber and air-storage types. This is due to the fact that in the very small cylinders of the small motors there is no large combustion chamber necessary for the jet injection process. This and other considerations led to the conviction that it is only with special constructions of the injection and combustion mechanism that Diesels could be built with cylinders such that the piston-swept volume is less than $^1/_2$ liter.

From this the author proceeds to the description of individual construction of small motors. Only some of the features of this part can be abstracted here. The Humboldt-Deutz Motor Co. has recently developed small Diesels equipped for burning domestic fuels, such as brown coal and bituminous-coal-tar oils. The smallest Deutz Diesel is a high-speed horizontal fore-chamber type producing 4 hp at 1200 rpm with a bore of 80 mm, stroke of 110 mm, and an output of 7.25 hp per liter at a pressure of 5.5 atm up. These figures would indicate that the fore-chamber type of Diesel, which has been lately developed for burning low-grade fuels and showed up very well in the utilization of the heat content in the fuel or specific fuel consumption, stands out well in competition with other Diesel-engine constructions in reference to load capacity, which means maximum value of the average effective pressure p_e and output per liter. For industrial purposes where a larger power output is required the Deutz company has a horizontal, slower running, fore-chamber machine built with a camshaft located along the longitudinal axis of the motor. This engine is available in sizes from 14 hp at 700 rpm to 40 hp at 400. The same company also builds a vertical motor for outputs from 6 to 9 hp, the former at 1000 and the latter at 1500 rpm.

The Güldner motors are built primarily for agricultural and industrial purposes. They are of the horizontal type equipped with evaporative cooling. These machines are provided with Lanova air storage. It is claimed that this latter device is very well adapted for small Diesel engines and permits a highly improved utilization of the space in the cylinder for purposes of power generation. Quite recently a four-cylinder Lanova motor-vehicle engine was built with an output of 40 hp at 1200 rpm and piston-swept volume of 1.27 liters per cylinder. It is started on gasoline with a greatly reduced compression pressure and can be then shifted to running as a Diesel. The starting is done by hand, which means elimination of such electrical appliances as battery and starter

More attention has been recently paid in small Diesels to the matter of reliable

starting, which led to the installation of ignition-assisting devices even in the case of air-storage motors, which, it is said, can be easily started even in very cold weather by reducing the compression pressure. The small Diesels of the Munich-Sendling Co. built in sizes of 7.10 and 15 hp use the Acro air-storage system. As they are intended chiefly for use in agricultural and industrial plants, they are built as horizontal single-cylinder four-stroke-cycle type with evaporative cooling. The piston is of light-weight metal. The starting is done by hand, the compression pressure being reduced by a spring-loaded decompression lever and is so maintained until a suitable velocity is reached. The Sendling small Diesel produces 7 hp at 1000 rpm as the mean effective pressure of 5.5 atm abs and with cylinders of 100 mm bore by 146 mm stroke.

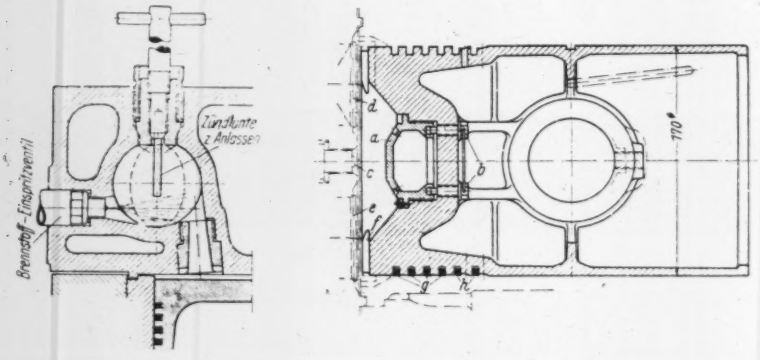


FIG. 2 (LEFT) TURBULENCE CHAMBER OF THE LINKE-HOFFMANN-BUSCH SMALL DIESEL ENGINE

FIG. 3 (RIGHT) PISTON OF THE HIGH-PRESSURE JET-INJECTION FOUR-STROKE DIESEL ENGINE OF THE LINKE-HOFFMANN-BUSCH CO. WITH AIR STORAGE IN THE PISTON

(*Brennstoff-Einspritzventil* = fuel injection valve; *Zündlunte z. Anlassen* = starting ignition torch; *a* = air storage chamber in piston; *b* = attachment of air storage chamber; *c* = fuel injection nozzle; *d* = inlet valve; *e* = exhaust valve; *f* = valve pocket; *g* = piston rings; *h* = oil-sweep rings.)

The small motor of the Linke-Hoffmann-Busch Company, Breslau, works on the four-stroke cycle. Machines for the larger output are equipped with direct high-pressure jet injection, using a multiple-passage nozzle. Smaller machines are equipped with nozzles which inject the fuel into a special turbulence chamber (Fig. 2). Some of the horizontal type engines are equipped with direct injection with an air-storage chamber located in the piston (Fig. 3).

The smallest motor equipped with the turbulence chamber runs at 1250 rpm and has a bore of 95 mm, stroke of 120 mm, and a piston-swept volume of 0.85 liter. A peculiar feature of the Linke-Hoffmann-Busch motors consists in the fact that being equipped with a device for taking away the oil mist by suction through an automatic air-release valve, all possibility of leakage of oil mist from the crankcase is precluded. Motors under 20 hp are started by hand and above that by compressed air. The air bottles are refilled by the motor when it is running. The original article shows a locomobile that is equipped with such a motor.

The horizontal Modaag Krupp four-stroke-cycle Diesel was built for comparatively low speeds, 400 to 550 rpm. In order to facilitate starting it by hand a special device was installed wherein by means of an appropriate gearing an air-release valve which is opened to reduce the compression pressure is closed automatically after six revolutions, so as to produce ignition of the fuel.

Of unusual construction are the two-stroke-cycle engines built by the Junkers Diesel Motor Co., Scharfenstein. They are valveless, port-operated, opposed-piston engines, the smallest unit producing 8 hp at 1000 rpm. The piston-swept volume, taking both pistons into account, gives 0.69 liter, which for the maximum output of 12.5 hp at 1500 rpm provides the unusually high volumetric output of 18 hp per liter, as well as the average pressure p_e = 5.4 atm abs, which is extremely favorable for two-stroke cycle engines. A notable feature of this motor is that notwithstanding the very small size of its combustion chamber it is equipped with jet injection. Another feature of the engine is the very good equalization of moving masses resulting in absence of violent vibration. (Prof. A. Loschge in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 10, March 9, 1935, pp. 317–322, 23 figs.)

MACHINE SHOP PRACTICE

Measurement and Specification of Surface Finish

THIS paper deals with surface finish from the standpoint of size and shape of the irregularities which constitute the surface. The method of measurement which the author used consists of tracing over the surface with a very sharp point and magnifying and recording the movements of the point so as to obtain an enlarged record of the profile of the surface. The instrument used was developed by the Physics Laboratory of the University of Michigan. It is known as the profilograph and has been generally described in a paper by E. J. Abbott and F. A. Firestone, published in MECHANICAL ENGINEERING, September, 1933, pp. 569–572.

The article here abstracted shows to scale profilograms of the surface irregularities of three typical finishes. The outstanding feature of all three surfaces is clearly the extreme bluntness of the irregularities. In each case the width of a hill or valley is from 10 to 50 times its height and this seems to be a general characteristic of all surfaces measured. The second feature of machined surfaces is the wide range in the size of irregularities. On rough-boring operations and the like the profile may have a depth of 0.004 to 0.005 in., while on finely finished parts such as piston pins, gages, and the like, the irregularities may be of the order of $^{5}/_{1,000,000}$ths, a factor of nearly 1000 to 1 between coarse, roughing operations and fine, finishing operations. A third feature of surface finish is the extreme range in the shape of the profiles. On many surfaces no two of the irregularities are alike and the size may vary by a factor of about 10 to 1 in a distance of a few thousandths of an inch of profile. On some surfaces the profile curves are very irregular, while on others they are very regular, and there are many other differences between surfaces.

As regards specification, after examination of the profilograms of practically all of the usual machining and finishing operations, it was decided that the best approach to specification is the rate at which the bearing area of the surface increases as the upper part of the profile is removed. Measurements were made of the increase of bearing area with depth on a number of profilograms, and the following specification devised on the basis of these measurements. It was found that most of the peaks on a surface are removed when the bearing area is 25 per cent, and that when the bearing area is 75 per cent only the deeper valleys

remain. Accordingly, a surface is defined in terms of three heights as follows:

Peak number—the height between the 2 per cent and 25 per cent bearing area.

Medial number—the height between the 25 per cent and 75 per cent bearing area.

Valley number—the height between the 75 per cent and 98 per cent bearing area.

All three numbers are given in inches; preferably, in millionths of an inch for convenience. The 2 per cent and 98 per cent limits were chosen to minimize the effort of a single prominent irregularity. This specification takes no account of the horizontal spacing of the irregularities. If it is desired to do this, it appears that the number of times the profile curve crosses the 50 per cent bearing-area line in a given distance would be a good rating.

The author discusses next the surface waviness and then proceeds to a consideration of practical methods of rating finish. Methods hitherto suggested have been microscopic examination, profile microscopic examination, profile-section method (a specimen is carefully copper-plated, cut so as to expose the profile of the surface, and the cut carefully polished, whereupon the profile can be examined microscopically), pencil-lead method (roughness of surface is estimated by the rate at which a pencil lead is worn away when it is drawn over the surface at a certain speed under a given pressure), electrical pick-up method, and visual comparison with profilographed standards.

The original article shows profilograms of several typical surfaces bringing out differences in size and shape of irregularities. Practical attention is called to the difference in looks between the surface of a bore in cast iron and the same followed by partial hone. (E. J. Abbott, Research Physicist, University of Michigan, in *S.A.E. Journal*, vol. 36, no. 3, March, 1935, pp. 112–116, 4 figs.)

Brazing With Silver Solders

IN THE specifications for silver solders of the A.S.T.M. (B 73-29) the content of silver runs from 10 to 80 per cent. These alloys have high tensile strength and produce malleable castings which can be drawn into various sizes of wire or rolled into sheets of different thicknesses, thus allowing the solders to be supplied in the most convenient form for any particular class of work. The original article gives a liquidus diagram of silver-copper-zinc alloys. The importance of knowing both the melting and flow points of the particular alloy used for soldering is emphasized. The solders containing lower percentages of silver have higher flow points and therefore do not give a good factor of safety if used for brazing metals or alloys that may be seriously damaged by the higher temperatures. In such cases the use of solders having higher percentages of silver and lower flow points are to be preferred. The resistance to certain types of corrosion is greater in solders of high silver content.

There are different types of electric-resistance heating devices available by which the heat is applied directly to the joint. Thin sheets of silver solder can be inserted in the joint and the principal advantage over ordinary welding is the lower temperature required to flow the solder. Many different types of joints can be made with this method and by using silver solders exceptionally strong joints can be obtained at relatively low temperatures.

Proper control of the heat is an important factor in obtaining uniform and strong joints. Investigations have shown that the best silver-soldered joints are obtained when there is some degree of diffusion between the solder and the metal. This diffusion is a time and temperature reaction and will vary with the type of metals being joined. With the majority of non-ferrous alloys, microscopic examinations will show this diffusion. With steels and alloys which have melting points several hundred degrees above that of the solder it is more difficult to determine positively this point, but the evidence obtained from the examination of a large number of specimens at high magnifications would seem to justify the statement that some degree of diffusion is present in all properly made silver-solder joints. An article published in *Metals and Alloys* in November, 1931, describes in more detail some work which was done in reference to the type of bond obtained with silver solders.

The flux is next discussed. A flux fluid and active at the temperatures obtained is recommended when making strong joints and it is advisable to protect both the surfaces along the joint and the solder with the flux.

It is a practice in some plants to assume that sufficient flux will adhere to the solder to clean off any oxide but the objection to this is the formation of oxides on the surface of the joint while the heating is being done; the time spent in protecting joints with flux during the heating is justified. Some users put flux along the joint but neglect to protect the solder because it requires an extra operation. It is a simple matter for the workman to dip the end of the solder into a small can of flux paste, and this added precaution against troubles from oxidation is advisable. One of the objections which is raised to spreading the flux along the joints is that the solder will flow over the surface at the sides of the joint where it is not needed. If the pieces to be joined are jigged so that the workman is free to apply the solder properly he will use only a sufficient amount to fill the joint and there should be no appreciable waste of solder from this source.

A number of special solders are mentioned. Part of the copper and zinc in standard silver solders may be replaced by nickel or manganese or both. Some of these alloys are not as free flowing as the regular silver solders, but satisfactory joints can be made with them at approximately the same temperatures. One of the fields where these alloys might find more extensive use is in brazing stainless steel. It is noted in this connection that strong joints in stainless steel can be made with several compositions, but the temperatures required for the use of silver solders come within what has been generally accepted as the critical range where carbon precipitation occurs. This is probably one of the reasons why silver solders have not been more widely used. It is possible to produce a malleable and ductile silver solder containing sufficient combined zinc and cadmium to bring the flow point below 1200 F. A silver solder which will flow at temperatures below 1000 F is also discussed. The problem does not seem to have been definitely solved. (Robert H. Leach, Mgr., Handy and Harman, in *The Welding Journal*, vol. 13, no. 12, December, 1934, pp. 23–27, 1 fig.)

POWER-PLANT ENGINEERING

Recent Developments of the Industrial Turbine

THE term "industrial turbine" is here applied to turbines which are used for power generation in industrial works and which also supply a certain amount of steam at definite pressures for process work.

The commonest type of industrial turbine is the bleeder turbine, but in a number of cases where the greater part of the steam is required for process work, it is preferable to employ a back-pressure turbine which reduces the pressure of a certain proportion of the steam for process work and provides sufficient power to run the factory. Heavy steam requirements for process work will, in

many cases, lead to an overproduction of electrical power which can then be returned to the public supply mains.

The development of high-pressure steam plants has rendered it necessary to devise turbine designs for dealing with high-pressure steam which are also capable of insuring the maximum economy in the use of the steam. The development of the modern industrial turbine is thus, in general, characterized by the endeavor to improve the efficiency of the high-pressure stages at increasingly high pressures.

Prior to the advent of the high-pressure movement, the chief means of reducing high steam pressures was the Curtis wheel, and a particularly efficient machine is obtained if, instead of using a single Curtis wheel with two or three rows of blading, the heat drop is spread over a number of pressure stages, usually three.

The individual impellers which are in one piece with their shaft carry blading which operates on the reaction principle. This may lead to certain troubles which are discussed in the original article. It is known now that an increase in the steam pressure must bear a definite relationship to the volume of steam passing through the turbine if a certain value of the efficiency is to be attained. If the pressure exceeds the predetermined value, the efficiency will fall off rapidly so that the increase of the pressure results in no economic advantage. A safe rule of thumb which is also demonstrably correct in theory is that the steam pressure in atmospheres should be approximately double the volume measured in tons per hour. The original article contains two sets of curves for the determination of the most favorable quantity of steam per hour as a function of the working pressure, one for the condensing turbine and the other for a back-pressure turbine.

For larger values of the pressure drop a larger number of stages becomes necessary, the number increasing inversely as the volume of steam, that is, the higher the pressure. This necessitates earlier recourse to the double-flow system in the case of high-pressure turbines, i.e., the arrangement of the stages in two separate cylinders. For a time this practice was overdone. The influence of the steam velocity was overrated and, although only justifiable up to a point, engineers ended with a number of stages which could not even be accommodated in two cylinders. This was the period which saw the advent of turbines of three and more cylinders. Today, however, there is a marked tendency to economize space again, not only in designing industrial but also power-station turbines, and to return to the single-cylinder turbine which is cheaper.

For turbines of larger output the most suitable design is the arrangement of reaction blading on one single drum. With this design a flat steam-consumption curve at partial loads is also obtained by the provision of a regulating wheel with constant-pressure blading and partial admission.

An essential feature of impulse blading is the use of higher steam velocities and sharper deflection of the steam flow, whereas reaction blading works with smaller pressure differences and in consequence with low velocities and less sharp deflection of the steam. The blade efficiency of the latter type of turbine is therefore somewhat higher. However, the maintenance of a certain efficiency, inclusive of the leakage losses, necessitates the adjustment of a definite clearance between the rotating and stationary parts of the blading. In the case of the impulse turbine it is the axial clearance which is important, while in reaction turbines the radial clearance must not exceed a certain value.

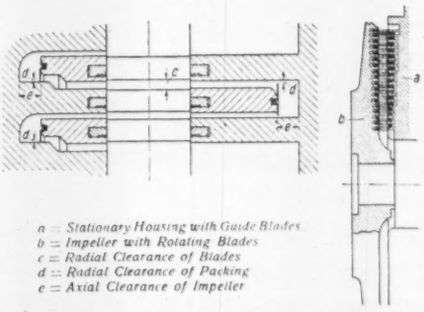

a = Stationary Housing with Guide Blades
b = Impeller with Rotating Blades
c = Radial Clearance of Blades
d = Radial Clearance of Packing
e = Axial Clearance of Impeller

FIG. 5 BLADE CLEARANCES AND DIAGRAM OF BLADING OF BACK-PRESSURE RADIAL TURBINE, SIEMENS-SCHUCKERT TYPE

In addition, however, the leakage losses at the points where the shaft issues from the housing and within it must be kept as low as possible. This means that the clearances must be as small as possible, necessitating the minimum distance of centers to the bearings in order to avoid bending of the shaft and to insure rigidity of the same. This places a limit on the number of stages of the axial turbine and hence on the efficiency obtainable per cylinder.

The author comes to the conclusion that in developing new designs the axial expansion must be kept as small as possible in order to insure that the necessarily small clearances shall be maintained at all temperatures and especially under sudden changes of the load. This has led to the complete abandonment of the axial arrangement of the blading and the adoption of the radial direction of the steam flow. The Siemens-Schuckert Company then undertook the development of designs intended to permit of the best possible utilization of the pressure drop at small outputs. In the design developed the blading is arranged radially in concentric rings, it being claimed that this design possesses a high degree of thermal flexibility. One or two rotors are used depending on the steam condition. Several designs are described in the original article—one with two disks with a definite number of blade rings. In the second basic type two impeller disks are used carrying concentrically arranged blading usually with nozzle regulation. The twin-wheel turbine is usually designed for the so-called U-flow arrangement of the steam which means that the steam enters the first set of blad-

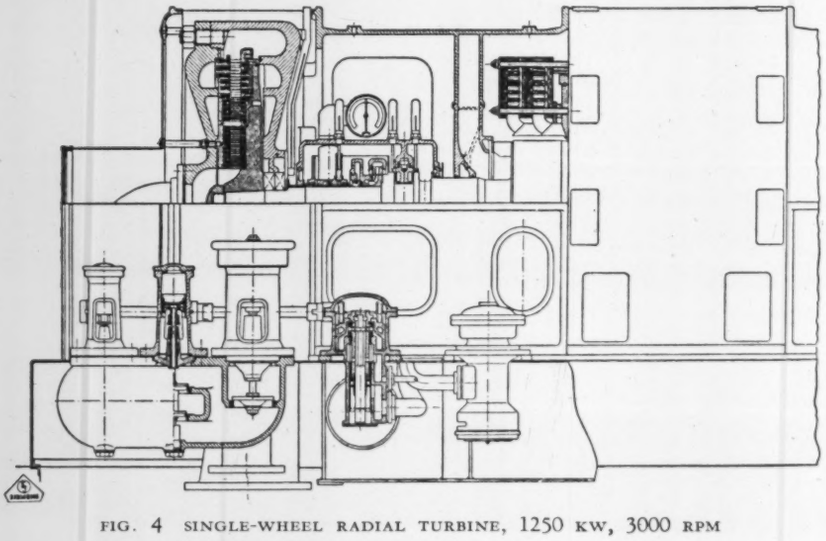


FIG. 4 SINGLE-WHEEL RADIAL TURBINE, 1250 KW, 3000 RPM

ing from the outside and flows inward, the direction being reversed in the second set of blading. With such an arrangement and proper equalizing labyrinth the rotor is subjected to practically no axial thrust. The general design of these turbines is shown in Fig. 4.

The blading (Fig. 5) is the result of a new process of manufacture. The runner blades are fitted to the disks in concentric rings, while the guide blades are fitted to special carriers. Special attention has been paid to insure uniform expansion. By suitable choice of the pitch diameters and angular setting the ratio of the blade lengths has been maintained practically constant over the whole range of expansion, which has a very favorable effect on the steam flow. The fact that the blades are connected to the disks by necks of small section prevents the dissipation of the heat into the iron masses, thus preventing unnecessary heating of the disks and consequently also deformation of these or the guide rings. The design is specially suitable for operation at very high temperatures, and it is distinguished for the short time in which it enables the turbine to run up to speed. The blades are manufactured from high-grade alloy steel on modern hydrodynamic principles, and have streamline form, so as to insure low losses at part load.

The same design can also be used for the high-pressure stages of bleeder turbines. The space between the two impellers can be used for a connection for live or bled steam. The low-pressure cylinder may be provided with nozzle regulation, that is, a Curtis wheel with adjacent drum part, which, in conjunction with reaction blading, insures good utilization of the low-pressure steam. Where the latter is not desired the low-pressure cylinder may be made to consist of a very few stages, usually only two, which can be accommodated in the high-pressure part, the steam being fed through low-pressure valves and nozzles to these last few stages. For turbines of this type a new kind of oil-hydraulic governor is used which works on the principle of volumetric change at constant pressure. (Dr. of Engrg. H. Melan, Siemens-Schuckert, Central Station Dept., in *Siemens Review*, vol. 11, no. 1, 1935, pp. 1–8, 19 figs.)

Unusually Large Diesel Engine

RECENTLY a double-acting two-stroke-cycle Diesel engine with a maximum output of 13,700 bhp was tested at the Works of Sulzer Bros., Ltd., Winterthur. This engine is intended for the French Company's power station at Shanghai, China, and is claimed to be the largest Diesel yet designed. It is built for a continuous output of 11,400 bhp, has eight cylinders, and runs at 136 rpm. Fuel injection is by air supplied by two three-stage compressors on the engine. This method of injection was adopted in order to use fuel with a high asphalt content. The scavenging air is provided by a double-acting tandem pump integral with the engine.

At the upper cylinder end fuel is introduced into the combustion space through a single fuel valve. The lower combustion space has two pockets in the cylinder cover on the lowest and coolest points for fuel valves. All valves including a safety and a pneumatically operated starting valve located in the lower cylinder cover are arranged with vertical axes so as to obviate uneven wear. Each upper and each lower combustion chamber has its particular fuel pump with eccentric drive and regulating mechanism. Fuel is delivered to each valve during the early part of the compression stroke and remains there until admitted. Quantitative regulation is effected by the governor with varying stroke of the suction valve. The engine is controlled by means of a handwheel, an indicator showing the various positions. After one turn from the position of rest, starting air is admitted and the injection-air stop valve is opened. The engine revolves and a further turn causes fuel to be delivered to the upper cylinder ends which begin to fire. By further turning the handwheel, starting air is cut off and fuel successively delivered to the lower cylinder ends. The normal starting air pressure is 425 lb per sq in., but a pressure of 220 lb per sq in. is sufficient to start up. To stop the engine, two further turns are given to the handwheel, whereby the fuel pumps are put out of action, injection air is cut off, and the piping vented.

The increasing power of Diesel units and the more general adoption of the double-acting principle with consequent larger resistance to governing influence call for more powerful governing action than is possible with mechanical means. Governing systems employing servo-mechanism, therefore, become necessary. For the exacting conditions of parallel working, which the multi-cylinder double-acting engine with its small cyclic irregularity fully satisfies, a high degree of sensitivity and rapid operation are required for the governing organ. These demands are fulfilled by the hydraulic governor. The arrangement consists essentially of a pump driven directly from the crankshaft delivering oil at a pressure varying in accordance with the speed of the engine and a servo-motor acting on the regulating mechanism of the engine (i.e., the fuel pump by-pass valves, the fuel-needle lifting gear, and the air-compressor throttle). (R. W. Millery, *Modern Power and Engineering*, vol. 29, no. 2, February, 1935, pp. 27–30, 3 figs.)

Sodium Sulphite as a Means of Inhibiting Corrosion in Boilers

THIS is a method of chemical deaeration to which a good deal of attention has been called lately. A known amount of the material may be dissolved in a given amount of water and the solution fed periodically or continuously to the feedwater after it has passed through the mechanical deaeration equipment. It may be fed into the water with other chemicals. Periodic dosing is satisfactory if economizers are not used. When economizers are used it is necessary to carry a constant feed of the sulphite solution to prevent corrosion within the economizer because of the liberation of oxygen when heat is applied.

So far as the boiler itself is concerned it may be protected against oxygen corrosion by the maintenance of sodium sulphite in the water to the extent of about 30 ppm of water. A table is given in the original article showing the sodium-sulphite requirements. The author gives the method of calculating the theoretical requirements of sodium sulphite in water, some practical suggestions and a method for determining the amount of sodium sulphite present. The latter is described in detail. (K. R. Fox, Monsanto Chemical Co., St. Louis, Mo., in *Southern Power Journal*, vol. 53, no. 2, February, 1935, pp. 30–32, illustrated)

"Mulsifyre" Pipe System for Extinguishing Oil Fires in Power Stations

THIS system, developed in England, is so designed that a finely divided spray of water is directed on to the affected part. At first it may be thought that such an arrangement is unsuitable for use about high-tension electrical circuits, but tests carried out by the Central Electricity Board (Great Britain) in November, 1932, showed that a spray of this kind is non-conductive and that there is no danger in playing it on a 132-kv line. There is even no danger in playing it on to conductors working on this pressure from a short distance if the hose nozzle is earthed.

As regards the application of this system to generating plants and substations,

it is recommended that the turbines be protected by dwarf walls 2 in. or 3 in. high to act as a catchment area in the basement and that the whole of this area be commanded by a series of "Mulsifyre" projectors. Alternatively, the projectors can be mounted above and around the oil coolers, filters, tanks, and pipes, so that in the event of fire the whole of the exterior of this apparatus is directly bombarded by the emulsifying spray. (*Engineering*, vol. 139, no. 3601, Jan. 18, 1935, pp. 61–62)

Turbine Lubrication

THE author states that purification of lubricating oil in a modern plant is recognized as being more economical than running an oil until its characteristics make it imperative to provide a new supply. He lists the indexes for suitability of an oil and gives some information as to the removal of water from oil and on filtration.

The following operating data on large turbines are given. Temperature of oil from the oil cooler varies from 95 to 110 F but the return temperature to the cooler from either bearings or the governor system does not exceed 140 F and the majority run under 130 F. Higher temperatures accelerate oxidation. Most plants prefer to operate on a regular schedule of centrifuging—either a certain number of hours per day, varying from six to eight, or by-passing continuously five to ten per cent of the oil in flow and returning this oil directly back into service. Make-up oil is also added at varying rates per month. The periods of operation between complete withdrawals of oil vary, but since a heavily loaded turbine usually comes out of service once a year for an annual inspection, the oil is usually filtered annually. This period can, in some cases, be extended, as samples of oil are withdrawn periodically and indicate no material change upon close visual examination. Settling must be allowed before a comparison is made. In the case of Diesel plants lubricating oil receives more severe service, in particular because of cylinder lubrication, and records for municipal plants show a period of 3000 to 5000 hr between complete withdrawals and batch filtration. Continuous by-pass centrifuging is also employed in the latter plants.

When filling the oiling system with oil, it has proved wise to run this oil through a fine strainer before it reaches the turbine oil reservoir, and when a turbine is first started, to check carefully oil temperatures throughout the system on the regular operating thermometers before loading the machine. An operating convenience employed is the sight overflow, which gives the turbine operator a means of noting quickly whether or not the system is operating satisfactorily.

The author considers the possibility of separating bearing lubrication and governor oil as also promising. A separate pump located on the main operating floor and supplying non-inflammable fluid to the governor system would improve the fire-hazard situation. Diphenyl oxide is not satisfactory as it is inflammable though a good lubricant. (Gustav A. Gaffert, Asst. Prof. of Steam Engineering, Worcester Polytechnic Inst., in *Power Plant Engineering*, vol. 39, no. 2, February, 1935, pp. 99–101, 2 figs.)

Overall Station Heat Consumption as Affected by Condensing-Water Temperature

AFTER discussing the subject in general the author gives a series of charts showing change in heat rate due to change in circulating-water temperature, this being intended to show graphically the relation between economy and circulating-water temperature at different loads. Some of these curves are adaptation of manufacturers' vacuum-correction curves on the machine on which the tests were made, and show percentage of loss or gain in heat consumption above and below 1 in. abs exhaust pressure as a base. The curves of the second set are plotted from test data and show the percentage of loss or gain due to condensate temperature with 80 F (1 in. abs pressure) as the base. The equation used for determining points for these curves is given in the original article.

The curves of the third set are derived from the other two sets and show net gain or loss due to circulating-water temperature. It is readily seen from a study of these curves that the most desirable range of circulating-water temperature is as follows:

Load, kw	Circulating water, F
25,000	45 to 50
20,000	48 to 53
15,000	53 to 58

The results of these studies and the several years of operating experience were instrumental in obtaining an appropriation for building recirculating equipment. Since continuity of service is of paramount importance, and since ice at the intake had caused considerable trouble, even to the point of partial plant shutdowns, there was a double reason for desiring such equipment. The recirculation equipment consists of a floating structure having slots through which planks are lowered to shut off part of the flow of river water to the intake and to direct the flow of part of the discharge water back to the intake.

The recirculation was put into operation in the fall of 1932 with 40 F established as a desirable temperature at which to hold the circulating water. During the two years of operation with partial recirculation of condensing water through the cold months there has been no surface hazard whatever due to ice and no drop in efficiency. The approximate saving is calculated in Table 1 to be $4230.

TABLE 1

Average annual cost chargeable to extra labor on account of ice before 1933	$760.00
Annual loss due to drop in efficiency (basis, present conditions)	3870.00
	$4630.00
Annual maintenance expense on recirculating equipment	250.00
Chargeable to depreciation of recirculating equipment—25 per cent on $600	150.00
	400.00
Net gain	$4230.00

(C. F. Moulton, Asst. Operating Engr., Nebraska Power Co., in *Combustion*, vol. 6, no. 8, February, 1935, pp. 26–27, 3 figs.)

Flexibility of Boiler Operation

THE original article is entitled "Multiple Retort Gravity Underfeed Stoker." Speaking of the Battersea Power Station of the London Power Co., Ltd., the author states that some load-variation trials had been conducted on the Battersea boilers which reflected the flexibility characteristic of the stokers. In these the rate of steam flow was altered considerably for the purpose of testing the feedwater regulators. Figures were obtained which showed an approximate increase in steam flow equal to the full normal output of the boiler (250,000 lb per hr) in 9 min and to a reduction of the steam flow of about 300,000 lb per hr in 12 min.

The author refers also to tests carried out at the Westkraftwerke of the Berlin Electrical Supply Co., of Berlin, Germany. There are eight boiler units in the station, each having a normal evaporation of 265,000 lb per hr and a

maximum continous evaporation of 330,000 lb per hr.

The first flexibility test in this station was conducted on a boiler which after being banked for a period of $3^1/_2$ hr, was raised to normal rating of 265,000 lb per hr in 4 min 50 sec. As the load for the boiler under test had to be taken from the other boilers which were in commission, the rate of increase in load from the boiler under test was such that blowing of safety valves occurred.

Accordingly, further tests were planned with a boiler coupled directly and independently to a turbine and arrangements were made to feed the steam to that turbine in such a manner as would insure the maintenance of the best possible conditions approximating constant drum pressure.

While the boiler was steaming at 265,000 lb per hr the fuel feed and air supply were stopped and readings of steam output and steam pressure were taken every 10 sec during the ensuing fall in load. The boiler was then maintained in a banked condition for a period of 12 hr and at the end of this 12-hr period the forced and induced-draft fans and coal feed were started up in order that the boiler might be loaded as quickly as possible.

Readings on steam flow and drum pressure were made every five seconds during the load increase. It was found that the turbine could not take the steam quite as quickly as it was generated and there was a consequent rise in pressure during the rise in load.

The time required to reach the normal rating of 265,000 lb per hr was 53 sec and the load continued to rise thereafter to a peak of 360,000 lb per hr before returning to its normal output and thereafter continuing in service at this same output.

As regards improvements in design it is stated that the most important single factor will be further development of the science of metered air supply. This is now being evolved to operate on a semi-automatic basis and may finally be placed on a fully automatic basis.

As regards the use of high air temperatures with multiple-retort-gravity-underfeed stokers, it is stated that temperatures of 500 F are already being used in practice and it is expected that temperatures of over 600 F will be used safely in the course of time. (Paper by W. M. Dodds before the London Technical Group of the Electrical Power Engineers Association, abstracted through *The Steam Engineer*, vol. 4, no. 6, March, 1935, pp. 228–229)

REFRIGERATION

Specific Heats of Certain Liquid Refrigerants

THE author possesses a simple calorimeter particularly adapted for measuring specific heats of liquids at temperatures between 10 and 20 C. He has performed measurements on dichlorethylene, methylformiate, and vinyl bromide and believes that the average values which he obtained and quotes are accurate within ± 1 per cent. Dichlorethylene is used as a refrigerant in refrigerating machinery working with turbo-compressors. The technically pure material such as is found in the trade is a mixture of two stereoisomeres, namely, cis-dichlorethylene and trans-dichlorethylene. If it is subjected to fractional distillation, a more volatile fraction (I) where cis-dichlorethylene predominates is found together with a less volatile fraction (II) containing predominantly trans-dichlorethylene. These fractions show the following physical properties:

	I	II
Normal boiling point, C. .	49 to 50	56 to 57
Specific weight of liquid at 20 C, g per cu cm. . . .	1.265	1.283

When measuring the specific heats it was found that at an average temperature of about 15 C, material (I) gave c = 0.281 as an average of six observations, and material (II) c = 0.278 as an average of five observations.

Since the specific heats of the two isomeres do not differ much, one may for most practical purposes call c = 0.28 kcal per kg deg C, which is the specific heat of trade dichlorethylene.

In recent years much attention has been directed to methylformiate as a refrigerant and it is used, for example, in the domestic refrigerator of the General Electric Co. equipped with rotary compression. Data as to the specific heats of liquid methylformiate are contradictory and were therefore subjected to experimental verification. According to Berthelot and Ogier the average specific heat between 13 and 39 C is 0.516 while Müller has found 0.475 for the range of temperature between 0 and 20 C, and 0.478 for the range between 12 and 20 C.

As the average of five determinations with methylformiate purified by fractionation it was found that the specific heat at about 15 C is c = 0.483 kcal per kg deg C. Vinyl bromide has been recently suggested as a refrigerating medium for use with turbo-compressors. The author measured the more important physical properties of this material, among them the specific heat of the liquid and found that at 15 C c = 0.240 kcal per kg deg C. The general data of the tests are presented in Table 1.

TABLE 1

Material	Formula	Specific heat of liquid at 15 C, kcal per kg deg C
Cis-dichlorethylene	$C_2H_2Cl_2$	0.281 ± 0.005
Trans-dichlorethylene	$C_2H_2Cl_2$	0.278 ± 0.005
Methylformiate	$HCOOCH_3$	0.483 ± 0.007
Vinyl bromide	C_2H_3Br	0.240 ± 0.004

(Wilhelm Mehl, communication from the Institute for Refrigeration of the Technical High School in Karlsruhe, abstracted through *Zeitschrift für die Gesamte Kälte Industrie*, vol. 41, no. 9, Sept., 1934, pp. 152–153, *e*)

STEAM ENGINEERING

Investigation of Steam-Turbine Operation by Means of Compressed Air

THE author claims that recent progress in rheology due mainly to intensive research in the field of aerodynamics has not yet been felt sufficiently in steam-turbine engineering. This is due chiefly to the extreme difficulty of experimenting with high-temperature steam, high peripheral velocities, and small blade dimensions, which make the apparatus inaccessible, and to complications resulting from condensation of steam in the passages.

The author attempts to carry on research on steam turbines by using air instead of steam and by carrying on tests on enlarged scale models, in the belief that this presents an opportunity of seeing what is happening in the passages and of localizing losses. In order to make this possible, however, it becomes necessary to determine to what extent the substitution of air for steam is permissible. In other words, it is necessary to establish the similarity between the operation of the model on air and the actual turbine on steam. The treatment of this problem is mathematical and not suitable for abstracting. The conclusion to which the author comes is that in order to substitute one active fluid for another, such as air for steam, it is necessary that the two fluids should satisfy the following conditions: (1) Equal number of atoms; (2) equal Mach coefficients (the Mach coefficient is expressed by $M = c/a$, where c is specific heat of the fluid and a is the velocity of sound); and (3) the same Reynolds coefficient.

From this it would appear that the

matter of similarity is not an easy one. The geometric similarity of model and turbine can be attained comparatively easily, but the requirement that the Reynolds coefficient shall be the same in both cases is difficult to satisfy in practice. Moreover, without actually solving the appropriate differential equations or carrying out special experimental work, it is difficult to say what effect the difference of atomic numbers may produce. However, it is possible, at least in some cases, to determine what effect a variation of k may have on the results, k being the ratio of specific heat at constant pressure to specific heat at constant volume, i.e., $k = c_p/c_v$. This can be determined from the Zeuner equation.

In two different cross-sections f_1 and f differing states will prevail and the author proceeds to compare them. This is given in Equation [26] of the original article which can be materially simplified by assuming $M_1 = 0$, in accordance with the Bernoulli equation, M_1 being the Mach coefficient for the given state. The equation thus obtained incidentally does not contain k. In the first approximation (with M_1 small) the number of atoms in the fluid is immaterial, which means that substitution of air for steam is permissible. Equation [26] also shows that where the variation of cross-section f_1/f is the same, the relative pressure differences remain constant, which is vital for the solution of this problem. It may also with good reason be expected that frictional flow may be reliably measured, providing it is borne in mind that the Reynolds and Mach coefficients must be as nearly as possible the same.

The conclusion to which the author comes is that as long as the Mach coefficients do not exceed the range of from 0.5 to 0.7 and there is no great difference between the Reynolds coefficients, there is no material objection to the use of air instead of steam. In any event it is practically always possible to investigate by this method of substitution the processes in the high- and medium-pressure stages of turbines, though the applicability of air tests to the investigation of the low-pressure-range remains to be established. This does not deprive the process suggested here of practical value, particularly if it is considered that a material share of the losses is produced by leakage and short circuits. A method that would make these losses easily recognizable and measurable would be of great value even if its precision is not perfect.

The author gives next examples showing with what simple means experimental data can be obtained with air as an active fluid, and such as could be obtained with steam only after a laborious process and then probably only with a lower degree of precision.

The physical characteristics of air affecting tests on models, namely, kinematic viscosity required for the determination of the Reynolds coefficient and velocity of sound for the determination of the Mach coefficient, are given in the form of curves (practically straight lines) in the original article, and the corresponding values for superheated steam within the technically important range are given in two other groups of curves. The kinematic viscosity of superheated steam has been taken from measurements by Speyerer for a range up to a pressure of 10 atm abs and has been calculated from recent measurements of W. Schiller for the range of 30 atm abs with extrapolation for higher pressures and temperatures. The velocity of sound for various conditions of steam has been determined from the 1932 Mollier steam tables with $k = 1.30$ for live steam. As an example, the case of a two-housing steam turbine of recent construction and of 20,000 kw capacity is used. This turbine runs at 3000 rpm and is supplied with live steam at 30 atm abs and 450 C, working against a condenser pressure of 0.04 atm abs.

According to the curves in the original article the kinematic viscosity of the steam varies between the high- and low-pressure parts. For saturated steam at 1.5 atm abs, the kinematic viscosity is practically equal to that of air, namely, about 16×10^{-6} cu m per sec. In the last stages operating in a vacuum the viscosity increases approximately in inverse proportion to the pressure so that the last stages operate in a steam atmosphere, the kinematic viscosity whereof corresponds in a startling manner to that of machine oil (400×10^{-6} sq m per sec at 20 C) and glycerine (600×10^{-6} sq m per sec at 20 C).

Next is considered the effect of moisture in steam which makes the conditions particularly obscure and also makes it impossible to compare the case of steam with that of flow of homogeneous fluids.

From curves of velocity of sound in the original article, it appears that the Mach coefficients as applied to the guide parts and to the rotor blading in the high-pressure portion of the turbine are, in the majority of cases, so small that, according to normal theoretical considerations, the conditions of reliability of model tests with air may be considered as satisfied and the transference of the results to steam permissible. A comparison with tests described elsewhere in the article show further that in model tests with air, Reynolds' coefficients of the same order of magnitude are attained as are found in the high-pressure part of the actual turbine.

The remainder of the article deals with the application of model tests to guide rings and rotor blading, in particular the exit angle of the steam, may be abstracted in an early issue. It discusses also the measurement of pressure on the surface of the blades, recovery of exit energy, and measurement of velocity in direction and magnitude at the rotating wheel. The other matters covered deal with the flow in the exhaust-steam connection and the influence of wetness of steam. (Prof. J. Ackeret, Dr. C. Keller, and Dr. F. Salzmann, reprint from *Schweizerische Bauzeitung*, vol. 104, December, 1934, 13 pp., 24 figs.)

Elsinore Three-Cylinder Compound Engine

THE Elsinore Shipbuilding and Engineering Co. is known for its exhaust-turbine installations which proved themselves popular with Danish shipowners. It has now installed in the steamship *Gyda* its new three-cylinder compound engine working in conjunction with an Elsinore exhaust turbine.

The reciprocating engine is fitted with poppet valves on the side of the cylinders and has short, amply proportioned steam passages. Superheated steam is supplied at a temperature of 626 F and the feed-water temperature is 257 F, feed heating being in two stages. The three cranks are at 120 deg, and the weight of the pistons is the same for all three cylinders.

As in earlier applications of the Elsinore exhaust turbine, the turbine is arranged on the top of the condenser. It runs at 4000 rpm and through a single gear drives an intermediate shaft with a speed of about 360 rpm, the power being transmitted from this shaft through a chain drive to the large chain wheel on the thrust shaft, in which heavy springs are fitted. The chain wheel is connected to the thrust shaft through a spring-loaded plate coupling which permits disconnection of the turbine installation during maneuvering.

The object in the construction of this engine is to provide a short unit, the total length of the engine from forward end of crankshaft to after end of chain box being only 14 ft 4 in., which is claimed to be less than for any other steam engine of this horsepower and number of revolutions. The chain drive has proved to be very reliable and has the advantage that wear-down of the crankshaft does not affect the transmission from the turbine.

The specific fuel consumption per indi-

cated horsepower on a 15-hr consumption trial of the engine for the *Gyda* was 0.97 lb of coal of a calorific value of 13,500 Btu per lb, the total indicated horsepower being 1800 (1400 the reciprocating engine and 400 the turbine) at 116 rpm. The steam consumption, measured by means of calibrated tanks, was 8.4 lb per ihp-hr. (*Shipbuilding and Shipping Record*, vol. 45, no. 2, Jan. 10, 1935, pp. 36–37, 2 figs.)

Heat Transmission in Thimble-Tube Boilers and Water Heaters

THE author makes reference to a British government publication "The Calculation of Heat Transmission," by Margaret Fishenden and Owen Saunders. This volume contains a mass of data accumulated for the Department of Scientific and Industrial Research at the request of the Fuel Research Board. The book contains also many data of other experimenters.

A variety of tube-bundle arrangements, including different sizes and spacings of the tubes, have been considered and provide an opportunity for assignment of probable performance when selecting tube-bundle arrangements for practical boiler tests. A number of such arrangements is shown in Fig. 6. Correlated experimental results for forced convection between a tube bundle and a stream of air or other gases are given in the original article in Fig. 3 for the types of tube bundles shown in Fig. 6.

The plotted results disclose a generic similarity between the curves obtained, thus indicating that there are probably fairly simple general laws discoverable for the purpose of designing heat-transmission apparatus capable of giving results closely in arrangement with any specified and reasonable requirements. The diagrams in Fig. 3 of the paper referred to cover tests made with tube bundles containing tubes from 0.4 in. to 1.3 in. in diameter, gas speeds ranging from 3 to 45 ft per sec, and temperatures up to 550 F.

Generally, it was found that H (the mean heat transfer per unit time per unit area) for a tube bundle as a whole is approximately proportional to the 0.75-power of V, the mean velocity at the narrowest cross-section or clear space between the tubes in one row of a tube bundle; that H increases with the number of tube rows up to 5 and then may be regarded as remaining constant; that a staggered arrangement of tubes is to be preferred to a parallel or square arrangement; and that H is inversely proportional to some small fractional power of the diameter of the tubes forming the bundles.

The author presents typical curves intended to show how the value of H/θ (θ is the temperature difference between the gas stream and the surface of the tubes) changes with variation in the size of the tube and the velocity of the gas through the tube nest, the mean temperature of heat exchange being constant.

The author claims that with these curves it is possible to choose the values of gas velocity, tube diameter, and temperature of heat exchange so as to meet all the geometrical and thermodynamic requirements of any reasonable specification, providing not only the requisite amount of heating surface to effect the desired amount of heat exchange, but doing this with a minimum waste of weight and space, and with a very high value for H.

Other curves show clearly that the values of H/θ under equivalent conditions of tube size, temperature of exchange, and speed of flow were very much lower for bundles of fire tubes than for bundles of water tubes of the same size. The author claims that his curves show that the popularity of water-tube boilers is founded upon a substantial basis. In this connection, however, he refers to two arrangements of fire tubes in fire-tube boilers, both originated by St. George Kirke. Kirke's work extends over a period of some sixteen years. In 1932 Kirke investigated the effect of rate of heat transfer of passing hot gases through a sinuous fire tube. This research and that of earlier experimenters, who discovered that continuous change in motion of the gas improved the rate of heat transfer, had certain practical results, and the original article reproduces data for straight and sinuous tubes taken from Kirke's 1932 specification.

As regards water-tube boilers, generally, the experimental data already detailed make it clear that important factors in securing a rapid exchange of heat between the tube surfaces and the hot gases are (*a*) the use of small tubes, and (*b*) the obtaining and maintaining of a high gas speed past the tube surfaces, i.e., through the interstices between the tubes in the tube nests.

From this the author proceeds to a consideration of thimble-tube boilers. The amount of heat transmitted through the wall surface of any given fire tube or water tube is dependent upon the temperature difference between its surface and the gas flow passing it, other factors

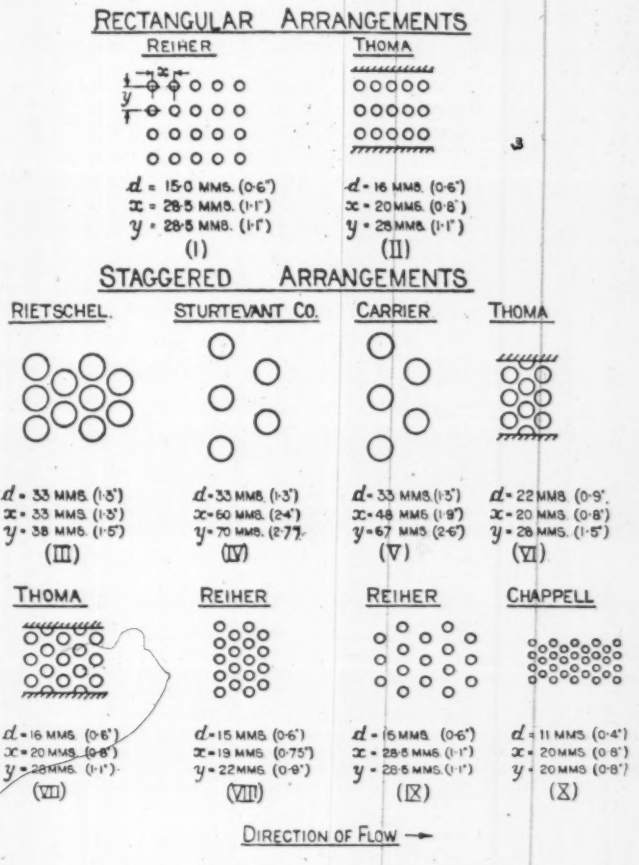


FIG. 6 ARRANGEMENTS OF TUBE BUNDLES

remaining unaltered; and assuming that conditions on the gas side of the wall surface of the tube remain unaltered, maintenance of this difference in temperature is dependent upon the efficacy of the means adopted to carry away the heat transmitted through the material of the tube; i.e., in the case of a boiler, upon the cleanliness of the tube surfaces, and upon the water circulation provided.

A brief history of the Clarkson thimble-tube boiler is given with a reference to waste-heat thimble-tube boilers.

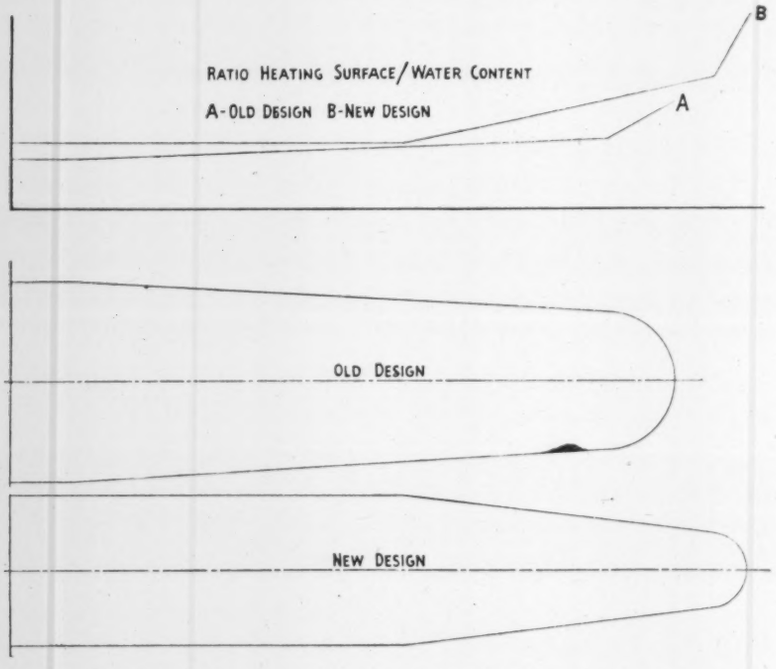


FIG. 7 DIAGRAM OF COMPARATIVE EVAPORATIVE EFFICIENCIES OF NEW AND OLD DESIGN OF TUBES FOR THIMBLE-TUBE BOILERS

The basic features of design of such boilers are presented by the author. The author found that the diameter of the thimble point is an important factor in effective steam generation. In tubes having points above 2 in. in diameter there is a distinct tendency for a ridge of scale to form toward the rear end of the hemisphere forming the point. This indicates that a certain circulation has taken place within the point of the tube prior to the generation of the steam. The author recommends, therefore, reducing considerably the size both of tubes and of the thimble points. Fig. 7 shows a thimble tube such as is advocated by the author in comparison with one of ordinary form, and Fig. 12 in the original article is a diagram comparing evaporative efficiencies of tubes of different sizes. It is claimed that the ratio of heating surface to water content varying as it does along the length of each of these tubes is very much in favor of the new design.

Fig. 13 in the original article shows elevations and sections of two gas passages in each of which this improved form of tube has been incorporated. In one the tubes comb practically the whole of the gas space. In the other, access is provided up through the central passage, two spiral devices being fitted in order to insure that the gas shall be thoroughly combed. Mention of the word "spiral" draws attention to another special feature of these new designs, the fact that with gases passing through at high speed —100 ft per sec is quite natural—a distinct swirl is imparted to the gases. The spiral devices shown are sometimes deliberately pitched to be of the opposite "hand" to this swirl so that there may be maximum interference with the gas streams in order to produce the turbulence which is so essential for obtaining good heat transfer. In other circumstances the pitch of the spirals may be arranged to be of the same hand as that of the tubes in order to promote the arresting of sparks. The general character of these spiral devices is shown in Fig. 14 in the original article.

The remainder of the article deals with details of boiler and water-heater design. This cannot be abstracted because of lack of space, but shows a small waste-heat silencer boiler to be used with internal-combustion engines, and downward-flow dry-bottom designs suitable for silencing and combing heat from the exhaust from internal-combustion engines, taking gases at from 1000 F down to 450 F. (E. F. Spanner, paper before The Institute of Marine Engineers read Jan. 8, 1935, *Proceedings*, vol. 47, part 1, session 1935, 18 pp., 24 figs. Abstracted from proof copy.)

WELDING

Flash Welding of Wide Sheets

THE development of the streamlined automobile body has led to a demand for sheet steel in widths up to 78 in. or more. Rolling mills in most instances are not prepared to furnish such wide sheets. Different methods have been tried to weld the sheets. In a European plant normal-size 20-in. gage sheets were welded by gas, but this experiment was not successful, as the sheets could not stand deep drawing. In the United States, experiments were made with resistance welding which also proved unsatisfactory. Flash welding was then tried, but the normal type did not prove entirely satisfactory, and the problem was finally solved by means of a slow weld and a different type of upsetting from that usual with the flash weld. Various factors had to be established and controlled in order to produce satisfactory welding; thus, it was found necessary to govern the slide motion in a manner different from that of the conventional flash welder.

When it came to finishing the sheets on a production basis it was found that the flash had to be removed on both sides and a perfectly smooth surface had to be obtained. This is done with a Morton flash trimmer. This machine is electrically operated, including clamping and reversing, and removes the flash on both sides, leaving very little material for grinding which is the next operation.

The original article describes a flash-welding machine capable of welding sheets 90 in. wide. The clamp pressure of 900 to 1000 lb per sq in. is applied hydraulically, and the upsetting is operated through a motor drive. Elkonite, which is a copper-tungsten alloy capable of withstanding these high pressures without deformation or wear, is used for the electrodes. Elkonite has a hardness in excess of 200 Brinell and a relatively high conductivity. The transformer has a capacity of 300 kw. (Peter W. Fassler, Consulting Welding Engr., Detroit, in *The Iron Age*, vol. 134, no. 12, Sept. 20, 1934, pp. 38–39. 3 figs.)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Suggestion Systems

AT THE 1934 Annual Meeting of The American Society of Mechanical Engineers two papers on suggestion systems for employees were presented and discussed. One of these papers, "Suggestion Systems," by Z. C. Dickinson, appeared in the November, 1934, issue of MECHANICAL ENGINEERING, and the other, "The Operation of a Suggestion System," by Virgil M. Palmer, was published in the December issue. Discussion on these papers was published in the February and March issues and is concluded as follows:

BY HENRY C. METCALF[1]

Professor Dickinson has said that he was dealing with "the positive and constructive ideas of workers about products and methods in the establishments where they work." "In general," he says, "These are distinct from the ideas of employees concerning the staple, controversial, collective issues of wages, hours, working conditions, and rights of organization on the one hand, and adverse criticism of tools, foremen, and fellow-workers on the other." He admits, however, that "these three classes of ideas in practice cannot be sharply differentiated."

The paper divides between what Professor Dickinson calls the "technical" and the "morale" benefits of the objectives sought through any suggestion scheme.

The few brief observations I shall offer apply, naturally, to the second group—the "morale" objectives. My own study and limited experience with suggestion systems led me long since to classify them with profit-sharing plans, bonuses, cut-and-dried training programs, and many other disjointed incentive schemes designed to increase output and profit, which seldom secure and sustain the individual interest or the group morale, because they are not dovetailed and joined into a working whole. I know there are isolated exceptions, due primarily to an unusually scientific organization, and humane, enlightened management. But, by and large, these suggestion schemes have played a very minor rôle in the development of effective employer-employee working relations.

And why? Because, in my judgment, business has been run without any basic philosophy—because "products" and "methods" have been put first, and the "staple, controversial, *collective* issues—wages, hours, working conditions, the rights of organization," the deep, abiding *human* issues, which ultimately must and will control, have been treated as secondary.

The major struggle through which industry is now passing is the attempt to reverse this emphasis. The basic idea of the New Deal is to make profits, products, methods the natural by-product of a business system built upon the recognition of *human personality*, in a scientifically organized and cooperatively administered business. This means a radical reversal of our past thinking as to what business is all about. From now on suggestion systems which are not organized and administered as an organic part of the new business philosophy evolving will, in the long run, meet with only indifference or opposition.

In brief crude outline I would state the following as basic guiding principles which should be borne in mind in the future organization and administration of any satisfactory suggestion system. I shall state my ideas categorically, since the allotted time does not permit elaboration:

(1) Basic human needs—elemental human want generators—health, job assurance, social security, knowledge, prestige, beauty, rightness, leisure—must be organically conceived and collectively realized in modern industrial relations.

(2) We must take our stand with one of two schools of philosophic thinking: The first, that ability is rare and most men are commonplace; or, second, that ability is everywhere, what is rare is opportunity. I take my stand unequivocally with the latter, and declare that the greatest single source of waste in the world is the undiscovered, untapped potential tastes, talents, enthusiasms of the millions of common laborers. Suggestion systems have not, generally speaking, been comprehensive and intelligent enough to touch this reservoir of wealth.

Professors Cleeton and Mason write, in their recently published volume, "Executive Ability:"

> The greatest waste in our modern industrial order is the neglect of human intelligence. We have learned to utilize labor and materials fairly well and while many further gains will be made, our present relatively high efficiency prevents revolutionary improvements. In utilizing the mental powers of employees, almost nothing is being done by the great majority of employers. Comparatively few are employed for thinking—management and specialists—and the rank and file of men seem to be looked upon as brainless automatons in many of our industries. The problem of morale alone makes such a stand untenable in modern industry. Furthermore, the latent power of constructive ideas offers the greatest potential field for exploitation by industry in the future.

(3) The best asset any business can have is the wholesome enthusiastic interest of every one of its employees in the problem of improving the quality of his own labor. It is the human-quality fact that counts. And only by making labor sharers in the industrial enterprise, will employers be in a strong position to appeal to the positive in their employees, who will then reciprocate by entering wholeheatedly into the job of producing the most and the best possible. So the "principal functions" which suggestion systems may perform, according to Professor Dickinson will counteract or nullify "the intangible costs."

Hope, sense of security, self-assertion, creativeness, group solidarity—now so lacking—must take the place of prevailing fear, suspicion, discord, and resulting inefficiency.

These basic human needs—the very foundation of any worth-while suggestion system—cannot be won from now on as

[1] Director, Bureau of Personnel Administration, New York N. Y.

the cultivation of any *individualistic* methods. Only the "group power of *collective intelligence*" will prove adequate. This means that workers as a collective body must increasingly share in planning, organizing, and administering any successful suggestion system.

(4) To be successful, suggestion systems must be made part of an organic new program of human relations based upon the genuine integrity—physical, intellectual, spiritual—of the individual.

Collective life as an aim in itself will get us nowhere. In the words of one of America's leading business philosophers: "What we care about is the *productive* life, and the first test of the productive power of collective life is its nourishment of the individual. The second test (which is the true test of any worth-while suggestion system) is whether the contributions of individuals can be fruitfully united.

The crux of our present business and industrial quarrels is not profits; it is not wages; it is the *joint control of industry*.

Quoting Miss Follett again:

As the most wholesome sign in the present treatment of industrial questions is the recognition that man with his fundamental instincts and needs is the very center and heart of the labor problem, so the most hopeful sign that we shall fully utilize the constructive powers which will be released by this psychological approach to industrial problems is the gradually increasing share of the workman in the actual control of industry.

Suggestion systems have too definitely tended to pit labor interests against the interests of capital. We are now headed for making capital and labor into one group—for the recognition of community rather than of individuals or class.

Man is the center and heart of the labor problem, and successful suggestion systems in the future must do their part toward bringing about the true democracy, which means that every man must be a creative industrial citizen. Business must increasingly realize that the development of men, of leaders, is its first obligation and primary responsibility.

The Dennison Manufacturing Company has had a long and unique experience with suggestion systems. Mr. Dennison has said:

We think that, by and large, while the actual value of the suggestions accepted more than balances the costs and awards, by far the most important advantage is the habit of mind the system cultivates; the habit of reaching for new ways and new things and of accepting continual improvement as the normal mode of life. We have had almost no suggestions of a critical or, as one might say, political nature in spite of the variety of assurances and safeguards we have provided. . . Suggestions, we believe, offer a real outlet for an expression of the incipient managerial tendency inherent in many people, especially as it applies itself to their tangible environment. We have not, however, in nearly twenty-five years found that they acted like afferent nerves to increase our sensitiveness.

This lack of critical or political nature of the suggestions received is due primarily to the lack of collective power necessary to bring them forth. One log will not burn alone. The inflexibility of the system, the fixed, individualistic ideas of executives and foremen, the fear of cost of changes of an experimental type where methods have become static—all tend to reduce the number of smaller and often larger changes and variations within a business. Business habits inhibit many variations of high potential value.

There is no doubt that the suggestion system holds possibilities for helping bring about the new employer-employee relations in process of development. And the workers will have confidence in them and cooperate in making them truly effective and productive if they have some voice in determining the terms on which the system runs, in determining which ideas shall be accepted, and how much reward shall be given for them. Joint action is essential here, as throughout the picture, for mutual understanding, mutual confidence, good-will, sustained interest, loyalty, and the morale of the group.

By Rensis Likert[2]

In the papers by Dr. Dickinson and Mr. Palmer two purposes or objectives that suggestion systems may serve have been stated. It would appear that in practice such confusion exists between these purposes that we might well examine their relationship to each other and to the operation of suggestion systems in general. The first objective is to obtain ideas which will make for an improvement in the product or in the operation of the organization. The second is to increase the morale, the interest, and the cooperation of the employees concerned.

Dr. Dickinson presents ample evidence to show that the technical value of the suggestions obtained is usually relatively little. Mr. Palmer's data corroborate this conclusion. An annual saving of $31,000 in a plant employing 7300 employees amounts to only $4.25 per employee. If the total cost of operating suggestion systems, including the time of operating executives, be deducted from the savings effected it would appear that the total net saving to the company is slight, if any. Apparently, then, from the standpoint of the first objective, namely, technical value or the economic value of the ideas, suggestion systems are scarcely warranted. They do not show sufficient profit to justify bothering with them.

Let us now examine their value when judged on the basis of the second objective. Here we want to see if their effect upon morale warrants using them. At the present time, as Dr. Dickinson points out, we do not have sufficient objective data to answer this question scientifically. We do have material, however, which permits serious consideration. Mathewson,[3] on the basis of an extensive study, concludes that soldiering on the job, or organized restriction of output, results in a 25 to 50 per cent curtailment in production. Pennock, Putnam, and Mayo's[4] work at the Hawthorne plant of the Western Electric Company corroborates this conclusion. Considerable additional corroborative evidence is available in reported studies.[5]

An incident which occurred in the Western Electric study has been reported by Mayo. One of the employees, after her confidence had been gained, mentioned that, in a particular department where girls operated machines to wind coils, the girls did 90 per cent of their output in the morning. During the afternoon they did only 10 per cent of their daily output, spending most of their time simulating work, especially when a forewoman was near. This statement was challenged by management as being impossible. They said that it was too easy to watch to see whether the girls were working. However, when a meter was placed in the line feeding the motors operating the machines it was found that 90 per cent of the energy was consumed in the morning.

We have, then, considerable evidence

[2] Assistant-Professor of Psychology, College of Engineering, New York University, New York, N. Y.

[3] "Restriction of Output Among Unorganized Workers," by S. B. Mathewson, Viking Press, 1931.

[4] "Improving Employee Relations," by M. L. Putnam, *Personnel Journal*, vol. 8, 1930, pp. 314–325; "Industrial Research at Hawthorne," by G. A. Pennock, *Personnel Journal*, vol. 8, 1930, pp. 296–313; "Growth of an Employee Relations Research Study," by G. A. Pennock and M. L. Putnam, *Personnel Journal*, vol. 9, 1930, pp. 82–85; "Human Problems of an Industrial Civilization," by Elton Mayo, Macmillan, 1934.

[5] For example see "Technical Vs. Social Organization in an Industrial Plant," by F. J. Roethlisberger and W. J. Dickson, Graduate School of Business Administration, Harvard University, 1934.

to show that production is drastically curtailed through restriction. This probably means that our actual production is somewhere near 50 to 75 per cent of actual capacity even when we are operating as what management regards as full capacity. This restriction is due to unfavorable morale and any procedure of management which can improve morale and therefore reduce restriction will, in most instances, be exceedingly profitable.

A suggestion system can be administered, if desired, in such a way as to contribute considerably to morale. Or, on the other hand, it can be conducted so as to increase dissatisfaction, arouse hostility, create distrust, and generally lower morale. To increase morale the suggestion system should be conducted in a way to make the worker feel he is being treated fairly, that the company is genuinely interested in him, willing to cooperate with him, and willing to pay him fairly for what he does. He should also feel that he has a chance to identify himself with the company in a way which is emotionally satisfying. If this program is carried out, morale will be improved. In addition to the morale benefits mentioned by Dr. Dickinson, will be found the development of a more favorable and friendly attitude on the part of the employee toward the company.

In a plant of 7300 employees it is reasonable to assume an annual payroll of at least $7,000,000. If morale is improved enough to increase output by only 1 per cent there would be an annual saving of $70,000. This is more than twice the saving actually realized on the technical value of the ideas as reported by Mr. Palmer. From the standpoint of the second objective we are apparently justified in concluding that the major value of a suggestion system can and should be in its influence upon morale.

If our major purpose in conducting a suggestion system is to build morale we would probably conduct it differently than most suggestion systems now seem to be conducted. It is significant that Dr. Dickinson points out that "... proposals that are primarily directed toward comfort and convenience of employees or to relieve grievances and even schemes for promoting health and safety usually play minor rôles." This probably reflects managerial policy. Likewise, Mr. Palmer's paper tends to emphasize the technical-value purpose of the suggestion system. Even the order of classification and the amount of the award are such as to emphasize this purpose of the suggestion system. Thus the minimum awards are:

Class 1	Improvement in product....	$10.00
Class 2	Reduction in costs.....	7.50
Class 3	Improvement in manufacturing methods.....	5.00
Class 4	Reduction in accident or fire hazard.....	2.00
Class 5	Convenience.....	1.00

Furthermore, if we really want to build morale, it might be decidedly worth while to pay for suggestions that have been adopted more than 5 or 10 per cent of the first year's savings.

However, if our fundamental purpose is to increase morale we should recognize the true place of suggestion systems. They are but *one of many ways* which if properly used will improve morale. They are but a part of a larger whole. In our efforts to improve morale there is no reason why we should restrict ourselves to suggestion systems only. On the contrary, we should approach this problem scientifically. Today, we have techniques whereby we *can* measure employee attitudes and behavior. Furthermore, we can determine scientifically what factors have produced these attitudes and behavior and what should be done to change them in a desired direction. In the order of the application of the scientific method the problem of the machine and its improvement was undertaken first. Then, under Taylor's leadership science was applied to the physical work of employees. Now it is time that we extended the scientific approach to include the mental and emotional life of the worker. If, through increasing morale, we can increase production 25 to 50 per cent with existing plant facilities, we cannot overlook morale. Management cannot call itself scientific until this problem is approached in a scientific manner.

BY LILLIAN M. GILBRETH[6]

Dr. Dickinson's paper is of value as stating some of the problems of suggestion systems clearly, and as submitting various useful measures for the effectiveness of a system.

If the objectives of a system may be divided into "technical" and "morale," this means that representation on the committee that handles the system would necessarily include management engineers and personnel people, as well as supervisors and workers. Perhaps the cooperation resulting from such joint participation would help to solve the pressing problems of making adequate job analyses and specifications of the work of the personnel man and the management engineer in the plant.

[6] Gilbreth, Inc., Montclair, N. J. Mem. A.S.M.E.

Motion study has been found useful in connection with suggestion systems, in pointing out new opportunities for suggestions, in training members of the committee to evaluate suggestions from the standpoint of technical validity and usefulness, and in increasing the technical value of suggestions to meet the growing appreciation of the morale value.

Mr. Palmer's paper is of great interest and significance, as presenting the theory and practice that has enabled the Eastman Kodak Co. to maintain its suggestion system effectively for so many years.

Maintenance of the suggestion system as well as of standard practice in other mechanisms of management can be assisted by the use of the "standing order," which lists the "what," "who," "where," "when," and "how" of anything to be done, as well as the supervision, and by the accompanying use of the "change order," which provides a mechanism of integrating changes into a system without losing momentum.

Incentives to making suggestions that are worth while should be both financial and non-financial. The financial incentives should be adequate, definite, positive, and prompt in functioning. The non-financial incentives should also be adequate, which includes being interesting, operating continuously, and creating group as well as individual satisfaction. The home-reading box, shop library, three-position plan of promotion, and fatigue-elimination campaign are typical of non-financial incentives that stimulate suggestions, guide them, and provide rewards.

The master suggestion record provides a means of reviewing suggestions, as it tells when the suggestion was made, who made it, when it was approved, when it was tried out, and when it was put into complete use.

The suggestion summary makes it possible to know the suggestion record of every member of the organization, and the suggestion record in every kind of work. If any organization is to get the most use from its suggestion system, from the morale standpoint, the master suggestion record is necessary; and if it is to get the most use, from the technical standpoint, the suggestion summary is necessary.

A suggestion system cannot be adequately evaluated simply as an isolated mechanism, but must be considered as a part of a management program and measured in terms of both general and specific usefulness, and of both intangible and tangible values.

A.S.M.E. BOILER CODE

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

SPECIFICATIONS S-24 TO MAKE THESE SPECIFICATIONS IDENTICAL WITH A.S.T.M. SPECIFICATIONS B 43-33. Revise as follows:

PAR. 3*b*. Second sentence. Revised:

Semi-annealed pipe, which is suitable for ordinary purposes, shall be furnished EXCEPT THAT RED BRASS PIPE MAY BE FURNISHED HARD DRAWN [unless otherwise specified].

PAR. 4. Add the following chemical compositions:

	ADMIRALTY METAL (NOTE)	RED BRASS
Copper, per cent.	70.00–73.00	84.00–87.00
Lead, max, per cent	0.07	0.07
Iron, max, per cent	0.07	0.07
Tin, per cent	0.90–1.20	0.15 maximum
Zinc, per cent	remainder	remainder

NOTE: THE IDEAL COMPOSITION FOR ADMIRALTY METAL IS 70 PER CENT OF COPPER, 29 PER CENT OF ZINC, AND 1 PER CENT OF TIN, AND BETTER TUBES WILL BE OBTAINED BY ADHERING AS CLOSELY AS POSSIBLE TO THIS COMPOSITION, PARTICULARLY AS TO TIN. IT DOES NOT, THEREFORE, SEEM WISE TO MAKE 1 PER CENT OF TIN THE MINIMUM BUT RATHER, IN ORDER TO OBTAIN AS NEARLY 1 PER CENT AS POSSIBLE, TO ALLOW SOME VARIATION UNDER 1 PER CENT AND MAKE THE MINIMUM LIMIT FOR TIN 0.90 PER CENT. OWING TO THE FACT THAT A MINIMUM OF 1 PER CENT TIN HAS HERETOFORE EXISTED, CASES WILL OCCUR, UNTIL THE PRESENT SPECIFICATIONS BECOME UNIVERSAL, WHERE THE TIN MAY EXCEED THE 1.20 PER CENT MAXIMUM. IT IS NOT CONSIDERED THAT THIS WOULD BE HARMFUL OR SHOULD BE MADE A CAUSE FOR REJECTION.

PAR. 6. Add the following as (*b*):

(*b*) SPECIMENS OF HARD-DRAWN RED-BRASS PIPE SHALL BE ANNEALED PREVIOUS TO THE HAMMERING TEST.

PAR. 7. Add the following as (*b*):

(*b*) SPECIMENS OF HARD-DRAWN RED-BRASS PIPE SHALL BE ANNEALED PREVIOUS TO THE FLATTENING TEST.

SPECIFICATIONS S-29. A.S.T.M. Specifications for Seamless 70-30 Brass Condenser Tubes and Ferrule Stock (B 55-33) will be incorporated in the Code as Specifications S-29.

SPECIFICATIONS S-30. A.S.T.M. Specifications for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56-33) will be incorporated in the Code as Specifications S-30.

SPECIFICATIONS S-31. A.S.T.M. Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44-33) will be incorporated in the Code as Specifications S-31.

PARS. H-63 and H-116. Revised:

H-63 (H-116) *Water-Column Pipes.* The minimum size OF FERROUS OR NON-FERROUS pipes connecting the water column of a steam boiler shall be 1 in. (The following sentence to appear in Par. H-63 only:) The steam connection to the water column of a horizontal-return tubular boiler shall be taken from the top of the shell or the upper part of the head; the water connection shall be taken from a point not less than 6 in. below the center line of the shell. No connections, except for [combustion] regulator, OR drain, or steam gage, shall be attached to A [the] water column or the piping connecting a water column to a boiler (SEE PARS. H-38 AND/OR H-91 FOR INTRODUCTION OF FEEDWATER INTO BOILER). If the water column or gage glass is connected to the boiler by pipe and fittings, a cross tee, or equivalent, in which a drain valve and piping may be attached, shall be placed in the water piping connection at every right-angle turn to facilitate cleaning. Water-glass fittings and/or gage cocks may be ATTACHED [connected] direct to a boiler.

PARS. H-64*a* and H-117*a*. Revised:

H-64 (H-117) AUTOMATIC *Low-Water Fuel Cut-Off* AND/OR WATER-FEEDING DEVICE. *a* It is recommended that ALL [each] automatically fired steam OR [and] vapor-system [heating] boilers be EQUIPPED [provided] with AN AUTOMATIC low-water fuel cut-off AND/OR WATER-FEEDING DEVICE SO CONSTRUCTED THAT THE WATER INLET VALVE CANNOT FEED WATER INTO THE BOILER THROUGH THE FLOAT CHAMBER, AND SO LOCATED AS TO AUTOMATICALLY CUT OFF THE FUEL SUPPLY AND/OR SUPPLY REQUISITE FEEDWATER WHEN THE SURFACE OF THE WATER FALLS TO THE LOWEST SAFE WATER LINE [of dependable construction].

SUCH A FUEL OR FEEDWATER CONTROL DEVICE MAY BE ATTACHED DIRECT TO A BOILER OR TO THE TAPPED OPENINGS PROVIDED FOR ATTACHING A WATER GLASS DIRECT TO A BOILER, PROVIDED THAT SUCH CONNECTIONS FROM THE BOILER ARE NON-FERROUS TEES OR Y'S NOT LESS THAN $^1/_2$ IN. PIPE SIZE BETWEEN THE BOILER AND THE WATER GLASS SO THAT THE WATER GLASS IS ATTACHED DIRECT AND AS CLOSE AS POSSIBLE TO THE BOILER; THE STRAIGHT-WAY TAPPING OF THE Y OR TEE TO TAKE THE WATER-GLASS FITTINGS, THE SIDE OUTLET OF THE Y OR TEE TO TAKE THE FUEL CUT-OFF OR WATER-FEEDING DEVICE. THE ENDS OF ALL NIPPLES SHALL BE REAMED TO FULL-SIZE DIAMETER.

PARS. P-104 and U-72*a*. Insert the following as the first two sentences:

"The plates may be cut to size and shape by machining or shearing, or by flame cutting if the carbon content does not exceed 0.35 per cent. If shaped by flame cutting, the edges

must be uniform and smooth and must be freed of all loose scale and slag accumulations before welding. The discoloration which may remain on the flame-cut surface is not considered to be detrimental oxidation."

PAR. P-198*a*. Revise definitions to read:

"C = 0.25 for heads forged integral with or butt welded to shells or pipes as shown in Fig. P-14$^1/_2$*d* and *e*, where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto, AND WHERE THE WELDING MEETS ALL THE REQUIREMENTS FOR CIRCUMFERENTIAL JOINTS GIVEN IN PARS. P-101 TO P-111, INCLUDING STRESS RELIEVING AND RADIOGRAPH EXAMINATION,"

"C = 0.30 for flanged plates attached to shells or [nozzle-necks] PIPES as shown in Fig. P-14$^1/_2$*c* by means of lap-RIVETED joints, where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto, AND WHERE THE RIVETING MEETS ALL THE REQUIREMENTS FOR CIRCUMFERENTIAL JOINTS GIVEN IN PARS. P-181 TO P-185,"

PAR. P-198*a*. Add the following:

"C = 0.50 for plates having a dimension d not exceeding 18 in. inserted into shells, pipes, or headers and welded thereto as shown in Fig. P-14$^1/_2$*i* and otherwise meeting the requirements for fusion-welded boiler drums including stress relieving but omitting radiograph examination, and where the end of the shell, pipe, or header is crimped over to an angle not less than 30 deg nor more than 45 deg, the crimping is done cold only when this operation will not injure the metal, and the throat of the weld is not less than the thickness of the shell, pipe or header wall or flat head, whichever is greater,"

PAR. U-39*a*. Add the following:

"C = 0.50 for plates having a dimension d not exceeding 18 in. inserted into vessels and welded thereto as shown in Fig. U-2*i* and otherwise meeting the requirements for the respective types of fusion-welded vessels including stress relieving when required for the vessel but omitting the radiograph examination, and where the end of the vessel is crimped over to an angle not less than 30 deg nor more than 45 deg, the crimping is done cold only when this operation will not injure the metal, and the throat of the weld is not less than the thickness of the vessel wall or flat head, whichever is greater."

PARS. P-198*a* and U-39*a*. Add the following:

"C = 0.75 for plates screwed into the end of a shell, pipe, or header (vessel) having an inside diameter d not exceeding 12 in., as shown in Fig. P-14$^1/_2$*j* (U-2*j*), where the hydrostatic end pressure on the head is resisted with a factor of safety of 5 both by the threads engaging the flat head and shell, pipe or header (vessel) wall and by the reduced cross-section of the threaded portion of the shell, pipe, or header (vessel). Seal welding may be used, if desired,"

PARS. P-198*a* and U-39*a*. Add the following:

"C = 0.30 for plates inserted into the end of a shell, pipe, or header (vessel) and held in place by some suitable positive mechanical-locking arrangement such as shown in Fig. P-14$^1/_2$*k* and *l* (U-2*k* and *l*), where all possible means of failure, either by shear, tension, or compression, due to hydrostatic end force are resisted with a factor of safety of 5. Seal welding may be used, if desired,

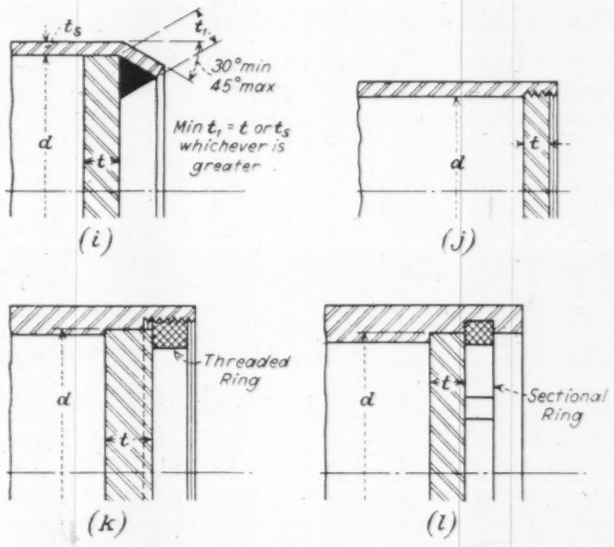


FIG. 14$^1/_2$ (U-2)

PAR. P-214. Add the following sentence:

"The rules in Par. P-216 shall be used to determine if staying is required."

PARS. P-268*d* and U-59*v*. Modify proposed revisions appearing in the April issue to read as follows but insert as item (3) of fifth section of Par. P-268*b* and as item (3) of Par. U-59*g*:

["*d* (*v*)] (3) NO CREDIT CAN BE TAKEN FOR THE ADDITIONAL STRENGTH OF MATERIAL HAVING A HIGHER TENSILE STRENGTH THAN THAT OF THE VESSEL WALL TO BE REINFORCED.

If the unit tensile strength of any material used for reinforcement is not AT LEAST equal to that of the vessel wall to be reinforced, additional reinforcement shall be added to compensate for the lower tensile strength, so that the total area of the cross-section of the reinforcement is in inverse proportion to the tensile strength."

TABLE A-6. In the 150-lb column for the minimum metal thickness of fitting, for the 1-in., 1$^1/_4$-in. and 1$^1/_2$-in. sizes change dimension "$^7/_{16}$" to "$^1/_4$.*". Also add a footnote to read: "*$^7/_{16}$ in. is recommended in A.S.A. Standard B-16e—1932."

PAR. A-21*a*. Revise last three lines to read:

"is 13 in. or less, the [bottom of the] fusible plug may BE [come] at a lesser distance than 1 in. above the upper row of tubes, but in no case shall the BOTTOM OF THE plug be located below the level of the top of the uppermost row of tubes."

PAR. H-67. Revise to read:

"H-67. Each plate of a completed boiler shall bear the plate maker's name with brand and tensile strength. [except that these marks need not appear on the butt straps after completion of boiler.] IF THE BOILER IS INSPECTED DURING CONSTRUCTION AND THE INSPECTOR ASSURES HIMSELF THAT THE PLATE MATERIAL CONFORMS TO CODE REQUIREMENTS, THE PLATE MAKER'S MARKS NEED NOT APPEAR AFTER COMPLETION OF THE BOILER."

PAR. H-81. Revise first sentence to read:

"Every boiler [the unsupported joints of] IN which THE PARTS SUBJECTED TO STRESSES DUE TO INTERNAL PRESSURE are JOINED [welded] by MEANS OF [the] fusion WELDING [process] shall be inspected during [its] construction at the shop where manufactured, by AN [a duly] authorized inspector."

PAR. U-13. Add the following as *e*:

(*e*) Tubes conforming with Specifications S-17 for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes may be used in unfired pressure vessels. The minimum gage thickness for such tubes for temperatures not exceeding 700 F, if under external pressure shall be as given in Table U-1A, and if under internal pressure shall be as given in Table U-1B.

PAR. U-13. Add the following as *f*:

"*f* Non-ferrous tubes conforming with Specifications S-29, S-30, and S-31 may be expanded or threaded into unfired pressure vessels."

PAR. U-22. Delete.

PAR. U-23. Renumber as Par. U-22 and insert the following as new Par. U-23:

"U-23. Pressure vessels and pressure parts of vessels may be fabricated by means of electric-resistance butt welding when the rules given in Pars. U-110 to U-114 are followed."

PAR. U-39*a*. Revise definitions as follows:

"C = 0.25 for heads forged integral with or butt welded to shells or pipes as shown in Fig. U-2*d* and *e*, where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto, AND WHERE THE WELDING MEETS ALL THE REQUIREMENTS FOR CIRCUMFERENTIAL JOINTS GIVEN IN PARS. U-67 TO U-79, INCLUDING THOSE FOR STRESS RELIEVING AND RADIOGRAPH EXAMINATION,"

"C = 0.30 for flanged plates attached to shells or pipes as shown in Fig. U-2*c* by means of CIRCUMFERENTIAL lap joints RIVETED, FUSION-WELDED OR BRAZED AND MEETING ALL THE REQUIREMENTS THEREFOR, INCLUDING THOSE FOR STRESS RELIEVING OF FUSION-WELDED JOINTS, and where the corner radius on the in-

TABLE U-1A MAXIMUM ALLOWABLE WORKING EXTERNAL PRESSURES FOR SEAMLESS AND LAP-WELDED STEEL TUBES FOR UNFIRED PRESSURE VESSELS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17

Outside diameter of tube in inches, D	Minimum gage—B.w.g. 17 t= 0.058	16 t= 0.065	15 t= 0.072	14 t= 0.083	13 t= 0.095	12 t= 0.109	11 t= 0.120	10 t= 0.134	9 t= 0.148	8 t= 0.165	7 t= 0.180	6 t= 0.203	5 t= 0.220	4 t= 0.238
1/2	300	...	...	...	...	...	...	...	...	...	...	...	...	...
3/4	165	450	...	...	...	...	...	...	...	...	...	...	...	...
1	100	300	500	...	...	...	...	...	...	...	...	...	...	...
1 1/4	...	225	390	...	...	...	...	...	...	...	...	...	...	...
1 1/2	...	175	305	445	...	...	...	...	...	...	...	...	...	...
1 3/4	...	140	250	365	485	...	...	...	...	...	...	...	...	...
2	...	110	210	305	405	...	...	...	...	...	...	...	...	...
2 1/4	...	...	175	260	350	440	...	...	...	...	...	...	...	...
2 1/2	...	...	150	230	305	390	460	...	...	...	...	...	...	...
2 3/4	...	...	130	200	270	345	420	490	...	...	...	...	...	...
3	...	...	115	175	240	305	375	440	...	...	...	...	...	...
3 1/4	...	...	...	155	215	275	340	400	460	...	...	...	...	...
3 1/2	...	...	...	...	190	250	310	370	425	480	...	...	...	...
3 3/4	...	...	...	...	160	210	270	340	390	445	495	...	...	...
4	...	...	...	...	...	180	240	300	360	405	455	...	...	...
4 1/2	...	...	...	...	...	135	180	240	295	350	400	445	485	...
5	...	...	...	...	...	...	135	185	240	290	350	390	430	470

The above table is based on the formula

$$\text{Tube gage} = 18 - [1.33 + 0.005\,(P\text{-}175)]D$$

but in no case is the tube-wall thickness less than that determined by the following formula:

$$t = \frac{(P + 275)D}{17{,}300}$$

where t = tube-wall thickness, in., P = maximum possible difference in pressure between the outside and inside of the tube at any time, lb per sq in., D = outside diameter of tube, in.

These rules may be followed for determining values intermediate of those given in the table and for values beyond the limits of the table.

side is not less than 3 times the thickness of the flange immediately adjacent thereto,"

PARS. U-69*a* and U-70*a*. Revise the wording of the parenthetical matter at the end of Pars. U-69*a* (page 57) and U-70*a* (page 62) to read:

"A RECOMMENDED FORM FOR RECORDING THE QUALIFICATION TESTS OF WELDING OPERATORS [sample data report sheet] appears on page 73;" and the heading of the form on page 73 to read: "RECOMMENDED FORM FOR MANUFACTURER'S RECORD OF QUALIFICATION TEST OF WELDING OPERATORS [DATA REPORT FOR VESSELS CONSTRUCTED IN ACCORDANCE WITH PARS. U-69 AND U-70.]"

PAR. U-73*f*. Revise to read:

"*f* Flat heads may be welded into any pressure vessel under the rules given in Par. U-39*a* [provided the welding meets the requirements for fusion welding for the class of service intended, except that radiograph examination may be omitted. When the fusion-welded vessel must be stress relieved, the flat head shall also be stress relieved.]"

PARS. U-110 to U-114. Insert the following new paragraphs:

RULES FOR ELECTRIC-RESISTANCE BUTT WELDING

"U-110. The plate for any part of a vessel to be welded by electric-resistance welding shall be of quality in accordance with Specifications S-2 for Steel Plates of Flange and Firebox Qualities for Forge Welding.

U-111. Where the entire area is welded simultaneously, without the introduction of extraneous metal, the maximum allowable unit working strength of the joint shall be 8000 lb per sq in. The finished weld shall be annealed preferably before removing from the welding machine.

U-112. Where the weld is made progressively and continuously over its entire length, the thickness of plate shall not exceed 0.15 in., and the offset of the edges, after welding, shall not exceed 60 per cent of the thickness of the plate. The maximum allowable unit working stress shall be 8000 lb per sq in.

Prior to the welding operation by this method, the edges of the plate and the electrical contact area shall be cleaned so as to free those surfaces from scale, oxide, or grease.

U-113. For temperatures higher than 700 F, the working stress allowable on electric-resistance-welded joints shall be reduced in proportion to the scale of reductions given in Table U-3.

U-114. Vessels whose joints are made by electric-resistance butt welding shall be tested in accordance with Par. U-64."

PAR. UA-16*b*. Revise last sentence to read:

"These rules may be applied to flanges of any diameter and for any working pressure, BUT ARE NOT INTENDED TO APPLY TO FLANGED CONNECTIONS WITH GASKETS EXTENDING BEYOND THE BOLT CIRCLE."

PAR. UA-22*b*. Revise first sentence to read:

"*b* Ring flanges may be fusion welded to a cylindrical shell or nozzle neck as shown in Fig. UA-2*d* AND CONSIDERED AS AN INTEGRAL FLANGE, provided that:"

TABLE U-1B MAXIMUM ALLOWABLE WORKING INTERNAL PRESSURES FOR SEAMLESS AND LAP-WELDED STEEL TUBES FOR UNFIRED PRESSURE VESSELS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17

Outside diameter of tube in inches, D	Minimum gage—B.w.g. 19 t= 0.042	18 t= 0.049	17 t= 0.058	16 t= 0.065	15 t= 0.072	14 t= 0.083	13 t= 0.095	12 t= 0.109	11 t= 0.120	10 t= 0.134	9 t= 0.148	8 t= 0.165	7 t= 0.180	6 t= 0.203
1/2	350	...	...	...	...	...	...	...	...	...	...	...	...	...
3/4	140	360	...	...	...	...	...	...	...	...	...	...	...	...
1	...	210	375	...	...	...	...	...	...	...	...	...	...	...
1 1/4	...	100	250	400	...	...	...	...	...	...	...	...	...	...
1 1/2	...	...	160	290	420	...	...	...	...	...	...	...	...	...
1 3/4	...	...	...	210	325	450	...	...	...	...	...	...	...	...
2	...	...	...	145	250	305	470	...	...	...	...	...	...	...
2 1/4	...	...	...	...	190	290	390	490	...	...	...	...	...	...
2 1/2	...	...	...	...	140	235	325	425	...	...	...	...	...	...
2 3/4	...	...	...	...	100	185	275	360	460	...	...	...	...	...
3	...	...	...	...	...	150	230	310	400	490	...	...	...	...
3 1/4	...	...	...	...	...	115	195	270	350	445	...	...	...	...
3 1/2	...	...	...	...	...	...	155	235	310	390	475	...	...	...
3 3/4	...	...	...	...	...	...	125	200	270	345	435	...	...	...
4	...	...	...	...	...	...	100	170	240	310	385	470	...	...
4 1/2	...	...	...	...	...	...	...	120	180	250	320	385	465	...
5	...	...	...	...	...	...	...	...	140	200	265	325	395	470

The above table is based on the formula, $t = \frac{(P + 250)D}{20{,}800} + 0.026$

where t = tube-wall thickness, in., P = internal pressure, lb per sq in., D = outside diameter of tube, in.

These rules may be followed for determining values intermediate of those given in the table and for values beyond the limits of the table but not in excess of 1000 lb pressure for seamless steel tubes or 500 lb pressure for lap-welded steel or wrought-iron tubes.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Marketing Industrial Equipment

MARKETING INDUSTRIAL EQUIPMENT. By Bernard Lester. McGraw-Hill Book Co., Inc., New York, 1935. Cloth, 5¾ × 9 in., 307 pp., 44 figs., $3.50.

REVIEWED BY ROBERT M. GATES[1]

THE distribution of capital goods has not had the intelligent direction that has been applied to design and manufacture in the industries producing them. Such is the indictment made by Bernard Lester in "Marketing Industrial Equipment."

A brief history of economic distribution brings us to the conclusion that in our great concentrated urge for technical and scientific development, which has resulted in this mechanical-electrical-technical age, we have not sufficiently developed our consideration of this growth or change upon society.

There have been two changes—technical development and social requirements. The author claims that we have not intelligently served the latter with the former. He makes an appeal for a greater concentration of effort to develop procedures of distribution so that society will be better able to utilize the developments and thus permit industry to serve better and to develop to a greater extent.

Why has this not been exploited before? The author claims that the fault is only at the door of management. Management has been too busy developing improvements to give the proper attention to the problems of distribution.

What will be the solution? The author outlines the basis upon which the facts should be collected and gives many specific suggestions and methods of procedure. His presentation is in most instances theoretical with a continuous evidence of practical knowledge as of one with actual experience, thus making a contribution to this subject in an easy, understandable form. This book should be used by all executives who have distribution of industrial equipment, as a problem.

[1] Vice-President, Superheater Company, New York, N. Y., and Past Vice-President, A.S.M.E.

Probability and the Physical World

NEW PATHWAYS IN SCIENCE. By Sir Arthur Eddington. The Macmillan Company, New York, 1935. Cloth, 5⅝ × 8½ in., 333 pages, $3.

REVIEWED BY W. A. SHEWHART[2]

WHERE is science today and where is it going? How does it attain its objectives? These questions demand the engineer's interest; the first, because the physics and chemistry of yesterday are in the engineering of today and the physics and chemistry of today will be in the engineering of tomorrow; the second, because the engineer must use scientific method wherever possible in determining what he should do for society as well as in doing it. On both of these scores the book under review contains much of interest.

Twelve of the fourteen chapters constitute the Messenger Lectures delivered at Cornell University during April and May, 1934, by the Plumian Professor of Astronomy and Experimental Philosophy at the University of Cambridge. No attempt is made to provide a systematic introduction to modern scientific thought and each chapter, with but one exception, deals with a separate theme and may be read independently. Hence it is possible for the author to begin each chapter on familiar ground, although the subject matter of each is such as to make it necessary for him to proceed to levels shrouded in some obscurity.

Starting with a discussion on science and experience he introduces us in the next chapter to the *dramatis personae* of modern science. Here we meet some of the newcomers of the last five years, such as the positron, neutron, and deuton along with some old friends such as the electron, proton, photon, and various radiations. The next four chapters have a common thread of interest in that they are concerned with the consequences of the statistical type of law first introduced into physics in the subject of thermodynamics. Of particular interest is the last of these four chapters which is devoted to an exposition of the physicist's viewpoint of probability. He differentiates between probability as a degree of belief and scientific or numerical probability. He takes the stand that the latter is not an uncertainty although our knowledge of it may be uncertain. Thus he says: " 'It is rather probable that the probability is . . .' is no more objectionable than the statement 'It is rather probable that the solar parallax is . . .' " It is only a few years since the subjects of probability and statistics were first given attention in courses in physics and chemistry. In fact, this is one of the first books on modern physics in English to devote a whole chapter to the philosophy of the concept of probability which is today recognized as a cornerstone in all scientific inference. The engineer of tomorrow in making use of the physics of today will likely find much of vital interest in these four chapters by way of introduction to some of the fundamental principles of probable inference. Here he will get some of the arguments for believing that the practice of science, as distinguished from the metaphysics of science, is at present based upon the concept of an objective probability which may, in most instances, be approached as a statistical limit.

From the viewpoint of scientific results these chapters present in a live manner, characteristic of the author, a bird's-eye view of several of the goings-on in modern physics. For example, in discussing the end of the world in the third chapter he starts with a consideration of the consequences of the thermodynamic concept of entropy, more or less familiar since 1852, and then indicates the significance of more recent theoretical studies of the expanding universe. In the concluding paragraph he drops his more serious efforts and risks a picturesque contrast of the old and new views of the end of the world; the old is that the universe will ultimately contract into a rather dense ball at a uniform temperature, whereas the new is that the physical world will end in an ever-expanding ball of radio waves, or, as he

[2] Chairman of the Joint Committee on the Development of Statistical Applications in Engineering and Manufacturing and a member of the technical staff of the Bell Telephone Laboratories, New York, N. Y.

says, in one stupendous broadcast. Two of these four chapters are devoted to a rather cautious discussion of determinism vs. indeterminism, and he makes it fairly clear that modern physics is *not* based upon determinism but instead on the concept of an *objective probability*.

Chapters seven to ten deal in turn with the constitutions of the stars, subatomic energy, cosmic clouds and nebulae, and the expanding universe. The author conducts us on a rapid tour through the galaxy of which we are a part; takes us into the heart of the atom to show us what is likely going on within these sub-microscopic regions; and then whisks us off on a tour of the universe whose external circumference is something like 4×10^{22} miles. In this rapid journey with such an eloquent and authoritative guide, one is introduced to many scientific facts of much interest in themselves. He presents reasons for believing that the prolific liberation of atomic energy must still remain in the dream stage for engineers although it is a common every-day fact for the astronomer. From an engineering viewpoint, however, perhaps the most useful thing obtained in this excursion is a glimpse of the working of scientific method. I think we cannot but be appalled at the success that has been attained in correlating the pointer readings of physics from the innermost parts of the atom to the outer boundaries of space by a method which seeks a knowledge neither of the human actors nor of the reality behind the pointer readings but a knowledge of the structure of the pointer readings.

From this viewpoint of methodology, chapters eleven and twelve are of outstanding interest. The first of these is perhaps the most meaty one in the book and presents some of the latest results of the author's attempt to find those constants of nature out of which we should be able to calculate every other constant displayed in natural phenomena. Here it is that we get a picture of some of the recent progress that has taken place in the unification of the theory of physical phenomena. Here also we get a feeling for the significance of Eddington's oft-quoted remark that "it is a good rule not to put overmuch confidence in the observational results that are put forward *until they have been confirmed by theory*." In other words, we see the working of the test of consistency among observed data as contrasted with mere statistical repetition being used to increase our assurance of the conclusions of modern physics.

In the second of these chapters on the theory of groups, he stresses the interest of the scientist in the structure or relationship of observable phenomena, a structure which from the viewpoint of modern logic is an a priori construction of formal logic and mathematics. He says, for example, "It is sufficient to say that what physics ultimately finds in the atom, or indeed in any other entity studied by physical methods, is *the structure of a set of operations*." This chapter on groups is introduced because Eddington believes group theory to be a more powerful tool than any other now known for digging down to the basis of physics. It is interesting as illustrating the ever expanding usefulness of the "pure" mathematics of yesterday in determining the structure of the observable phenomena treated by scientific method.

The two closing chapters touch upon the general relation of the physicist's world to the whole of experience—the relation of the pointer readings given by the *operations* performed by physicists to the *whole* of human experience. He recognizes the perceptions of the plain man, the moral consciousness of the good man, the sensitivity of the artist, the human valuation of all men, as well as the religious experience of the mystic as revelatory of reality. In so far as there are arguments for believing that any one of these forms of experience is *merely* subjective, the same may be said for all the others. Likewise, if one gives us information about the external world, so also do the others.

Such is briefly the author's view of the extensive and complicated world of experience in which we as engineers must work; such is the world which some enthusiastic engineers have ventured to assert can be charted by them, if it is not by others, through the use of scientific method. Possibly a study of the limitations of scientific method—even when applied to the pointer readings of the physicist—as revealed in this book may invoke caution on the part of all of us in expecting too much in the scientific conquest of the whole of experience.

All in all, this is a stimulating semi-popular book, charting some of the signposts along the new highways in physical science. A book that in the first half shows why probability and statistical theory play such an important part in the physics of today that will be the engineering of tomorrow; one that in later chapters emphasizes both directly and indirectly the significant rôle played by mathematical theory and formal logic in discovering the structure of pointer readings; and one that in the closing chapters clearly differentiates between the experience of the physicist and the whole of experience in which, incidentally, we who are engineers must work.

Psychometrics

PSYCHOMETRICS. A STUDY OF PSYCHOLOGICAL MEASUREMENTS. By Johnson O'Connor. Harvard University Press, Cambridge, Mass., 1934. Cloth, 6 × 9 in., 292 pp., 42 figs., $3.50.

REVIEWED BY LILLIAN M. GILBRETH[3]

THIS book should be of special interest to engineers because its writer is an engineer who has had experience in industry as well as in the colleges, speaks our language, and knows our needs. Written under a grant from the Jacob Wertheim Fellowship for the Betterment of Industrial Relations, of Harvard University, its 292 pages present a real contribution to thinking and research in this field. As Mr. O'Connor says, "This is a study in the human substance of industrial relations... An attempt to isolate and measure separable elements in the complex of human character. . . and to determine their significance in industrial affairs, thus contributing to smoother performance of the productive machine."

In typical engineering fashion, the thesis and findings of the book are stated in the 34-page introduction clearly and simply. Three main topics are discussed —executive characteristics, business and industrial application, and administration. The value of psychometrics is thus described: "Scientific discoveries have followed each such new achievement in the art of measuring.... If progress in human understanding follows the other sciences, no single step will contribute to better human relationship so definitely as the construction of accurate measuring instruments." "Reliability" and "validity" are defined, and the former given as the criterion used for the material covered by this book.

The executive characteristics listed are most interesting, i.e., large English vocabulary, many aptitudes, objective personality, accounting aptitude, aptitude for first position. The "many aptitudes" cover personality, tonal memory, engineering aptitude, accounting aptitude, tweezer dexterity, finger dexterity, creative imagination, inductive reasoning, and visual memory. The findings—

[3] President, Gilbreth, Inc., Consulting Engineers, Montclair, N. J. Mem. A.S.M.E.

that finger and tweezer dexterity are not necessarily possessed by the same person, and that many aptitudes may be a source of failure rather than success, by leading to restlessness and dissatisfaction—seem specially significant.

Much interest has been aroused by the findings concerning large vocabularies. "A large vocabulary is typical not exclusively of executives, but probably of all successful individuals." This is a challenge to all teaching, but especially to engineering education. Here is another challenge. "From the work which we have done thus far, it seems best, if the individual is to meet life successfully, not to try to change his personality." It is of course implied that the personality is satisfactory to the owner and to others! And again, "Success at the first undertaking gives confidence, a feeling of success which later becomes an executive characteristic." And for those who educate girls, "Women who attain executive responsibilities must have more ability than men, in order to gain equal recognition."

The bulk of the book deals with the techniques used for the studies on which the findings are based. These are presented in detail and with great care, and will be of special interest to engineers concerned with methods of measurement and the statistical techniques. It is a little disappointing to find definitions of skill, aptitude, and knowledge which mean that it is not possible to compare the findings of the work in these fields with those where different definitions are used. These are the definitions: "Aptitude—a gift for the task in hand, a flair fully developed at the time of physical maturity, at the age of 18 or 19, and therefore little altered by education or experience." "Skill—an ease of performance which comes with repetition, which follows from having performed an operation or some part of it before. . . . Skill is increased speed without change in method." "Knowledge—method, technique, and manner of executing." The sum of the three is given as ability. We who define skill as knowledge-plus-dexterity-plus-adaptability would like to see Mr. O'Connor use the same definition, as we value his work so highly.

The findings of the book can be read in a few minutes. The entire book takes a long time to read. But it is worth careful study, and the reader will find himself discussing and quoting it, using it for reference, and gradually making a large part of it a part of his thinking equipment.

Industrial Standardization

INDUSTRIAL STANDARDIZATION, by John Gaillard. The H. W. Wilson Company, New York, N. Y., 1934. Cloth, 6 × 9¼ in., 123 pp. $2.

REVIEWED BY EARLE BUCKINGHAM[4]

TO A GREAT extent, standardization, to the manufacturer, represents the reduction of a great variety of detail to routine or habit. This phase of standardization has existed from earliest times. We still shake hands in greeting although we have no suspicion of a dagger in the dexter hand of our acquaintance. Men still wear buttons on the cuffs of their coat sleeves, although they abandoned ruffles on their shirt sleeves long ago. Hence, habits blindly followed are not alone satisfactory for industrial standards. Such standards must be living, and not dead or asleep, and must progress with changing conditions.

This treatise on industrial standardization presents in a very interesting and readable form the evolution of standardization and its essential functions, and discusses the many characteristics of standards and specifications and their practical application.

This text should be studied by the management of any industry as well as those specializing in standardization activities; because in many ways systematic and continuous standardization can be made a profitable long-term investment, and to accomplish this end, requires the support and encouragement of the management, as well as the technical skill of the engineer.

Books Received in Library

AMERICAN SOCIETY FOR TESTING MATERIALS, Proceedings of the 37th Annual Meeting, Philadelphia, 1933. 6 × 9 in., vol. 1, 1325 pp., vol. 2, 943 pp., illus., diagrams, charts, tables, cloth, $6; half leather, $7 each. The proceedings are in two volumes. Part one contains the reports of committees, the "tentative standards" and the tentative revisions of standard specifications and tests. Among these reports are investigations of the effects of sulphur and phosphorus upon steel; of corrosion of non-ferrous metals in liquids and by galvanic and electrolytic action; of the effect of aluminum upon the qualities of zinc alloys for die casting; and of the service characteristics of light metals and their alloys. Part two includes the papers and discussions presented at the 1934 meeting, upon metals, cements, ceramics, masonry, paints, rubber and other topics. It also contains the Marburg lecture, on "Water as an engineering material."

DIE AUFWERTUNG DES WASSERGASES DURCH KARBURIERÖLE, by P. Schläpfer. STUDIEN ÜBER DIE UNTERSUCHUNG UND BEWERTUNG VON KARBURIERÖLEN, by P. Schläpfer and S. Schaffhauser. Eidgenössische Materialprüfungsanstalt an der E.T.H. in Zürich, Laboratoire Fédéral d'Essai des Matériaux Annexé à l'École Polytechnique Fédérale à Zürich. Bericht No. 68. Zurich, Switzerland, 1934. Paper, 8 × 12 in., 64 pp., diagrams, charts, tables. The two investigations here reported are concerned with the manufacture of carbureted water gas. The first presents the results of plant tests of the improvement obtained through carbureting oils and the conditions for maximum results. The second discusses the relations between the physical and chemical properties of a gas oil and its value as a carbureting oil.

DIE BEARBEITUNG DES ALUMINIUMS. By E. Herrmann and E. Zurbrügg. Leipzig, Akademische Verlagsgesellschaft, 1935. Paper, 5 × 8 in., 106 pp., diagrams, tables, 4 rm. A little book of practical instruction for the metalworker upon aluminum and its alloys. The shaping of the metal by bending, drawing, stamping, turning, milling, etc.; methods of riveting, welding and soldering; surface finishing by mechanical and chemical methods; and methods of oxidizing, coloring and lacquering are described.

THE CHALLENGE TO LIBERTY. By Herbert C. Hoover. Charles Scribner's Sons, New York and London, 1934. Cloth, 6 × 8 in., 212 pp., $1.75. Mr. Hoover here discusses some of the pressing political and economic questions of the day and gives his criticism of current tendencies in the treatment of national problems. The achievements of the American system of government are described and compared with other systems of society.

DIESEL HAND BOOK. By J. Rosbloom. Second edition. Diesel Engineering Institute, Jersey City, 1935. Leather, 5 × 7 in., 543 pp., illus., diagrams, tables, $5. A practical book of instruction for engineers and students on modern Diesel engineering, land, marine, locomotive, aero, automotive and portable installations. It is a practical text and reference book for the operating engineer. Presented largely in questions and answers, the text covers the information needed in simple language.

INDUSTRIAL FABRICS, a handbook for engineers, purchasing agents, and salesmen. By G. B. Haven. Wellington Sears Co., New York, 1934. Leather, 6 × 8 in., 538 pp., illus., diagrams, charts, tables, $2. This book brings together much information upon the physical properties of the heavy cotton fabrics used for industrial purposes and upon the methods of testing them. The types of cotton, methods of manufacturing, the uses, organization and properties of industrial fabrics are described. Laboratory design and practice are presented, and a large number of specifications and test methods are given.

KRAFTFAHRTECHNISCHE TAGUNG, 1934. Vorträge und Aussprachen, V.D.I. Verlag, Berlin, 1934. Paper, 8 × 12 in., 58 pp., illus., diagrams, charts, tables, 5 rm. This pamphlet contains the proceedings of a meeting devoted to automobile engineering, held on October 29, 1934, by the Verein deutscher Ingenieure. Among the subjects discussed were lubrication, fuels, hydraulic and mechanical gears, streamlining, etc.

[4] Professor of Engineering Standards and Measurement, Massachusetts Institute of Technology, Cambridge, Mass. Assoc-Mem. A.S.M.E.

MACRAE'S BLUE BOOK consolidated with Hendricks' Commercial Register. 42nd annual edition. MacRae's Blue Book Co., Chicago, 1934. Cloth, 8 × 11 in., 3340 pp., illus., $15. Contains a directory of manufacturers and distributors of materials of all kinds, a classified list of materials, a directory of towns and cities, with their facilities for trade, and a list of trade names. The information is well arranged. The book will be useful to purchasers of materials generally.

PETROLEUM REGISTER, Sixteenth Edition. Petroleum Register Corporation, New York, 1934. Cloth, 8 × 12 in., 724 pp., diagrams, charts, maps, tables, $10. The register is a convenient compendium of statistical and trade information constantly wanted by those in the petroleum industry. It contains lists of refineries, refining companies, producers, marketers, jobbers, compound and grease manufacturers, pipe-line companies, trade names, natural gasoline plants, drilling contractors, etc. Statistics of production and consumption, imports and exports, refinery output, etc., for a number of years are given. Maps of the oil-producing regions of the world are provided. Other features include a directory of oil-company executives, the text of the Petroleum Code, and a buyers' guide to equipment and supply sources.

PRINCIPLES OF MOTOR FUEL PREPARATION AND APPLICATION. Vol. 1. By A. W. Nash and D. A. Howes. John Wiley & Sons, New York, 1935. Cloth, 6 × 10 in., 538 pp., illus., diagrams, charts, tables, $8. The first part of a comprehensive two-volume treatise on the subject, which describes present technique and also discusses future problems. This volume deals with the production of motor fuels by methods of distillation, cracking, extraction from natural gas, and hydrogenation. It also discusses methods of refining, storage and distribution, the production of benzol, alcohol fuels, and synthetic fuels. Excellent bibliographies accompany the various chapters. The book will be useful to producers and consumers of petroleum products generally.

REGELN FÜR ABNAHMEVERSUCHE AN DAMPFTURBINEN. (V.D.I. Dampfturbinen-Regeln D.I.N. 1934.) Aufgestellt vom Deutschen Dampfturbinen-Ausschuss beim Verein deutscher Ingenieure. Second edition. V.D.I. Verlag, Berlin, 1934. Paper, 8 × 12 in., 6 pp., tables, 1.50 rm. This pamphlet contains the rules for acceptance of steam turbines prepared by the Verein deutscher Ingenieure. This edition contains various changes from the previous one, which appeared in 1931.

RUBBER: ITS ANTI-OXIDANTS AND PRESERVATIVES. Science Museum, South Kensington, Science Library Bibliographical Series No. 151. A bibliography compiled by the Science Library and the Research Association of British Rubber Manufacturers. Science Museum, London, 1934. Cardboard, 8 × 13 in., 82 pp., 5s 7d, postage included. This bibliography contains some 1500 references, classified by the Universal Decimal Classification. The references are printed on one side only, so that they may be mounted on cards, if desired.

Science Museum, London. Board of Education. RUBBER EXHIBITION (November, 1934–April, 1935). Compiled by Rubber Growers' Association; His Majesty's Stationery Office, London (obtainable from British Library of Information, N. Y.), 1934. Paper, 6 × 10 in., 44 pp., illus., 6d; $0.20. In addition to a descriptive catalog of the exhibits, the handbook contains a good brief account of the history of rubber from its source to the finished product.

SCIENCE OF WORK. By M. S. Viteles. W. W. Norton & Co., New York, 1934. Cloth, 6 × 9 in., 442 pp., diagrams, $4. This volume provides a non-technical discussion of the applications of psychology to industry. Personnel selection, methods of training, the effect of various influences upon output, and similar problems of management are considered and the psychological factors involved in their solution are presented. The book has practical value for executives. There is an extensive bibliography. The author is Director of Personnel Research of the Philadelphia Electric Company.

STANDARD GEAR BOOK, Working Formulas and Tables in Gear Design. By R. Trautschold. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 314 pp., diagrams, charts, tables, $3. In preparing this book for machine builders and gear designers, the author has aimed "to supply the facts behind the important advances in commercial gear-production practices during the past quarter century, to reiterate the principles upon which the operation of the modern gear-generating machines and the art of gear designing are founded, and to show how and why transmission efficiencies of 99 per cent plus have been attained." The work is offered as a successor, to a certain extent, of Logue's "American Machinist Gear Book."

STAURAUMVERLANDUNG UND KOLKABWEHR. By A. Schoklitsch. Julius Springer, Vienna, 1935. Cloth, 6 × 9 in., 178 pp., illus., diagrams, charts, tables, 19.50 rm. The purpose of this book is to throw light upon some important questions that confront the designer of reservoirs and hydraulic power plants. These are the transportation of debris by running water, the silting up of reservoirs, erosion below dams and the dissipation of energy. Dr. Schoklitsch presents the results of extended experimental studies, supplemented by the work of other investigators, in a form for practical use. Bibliographies accompany each chapter.

STRENGTH OF MATERIALS. By J. E. Boyd. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 548 pp., illus., diagrams, charts, tables, $3.75. This text is intended to give the student a grasp of the physical and mathematical ideas underlying the mechanics of materials, together with enough of the experimental facts and simple applications to prepare him for subsequent technical subjects as given in books on machine design, reinforced concrete, or stresses in structures. This edition has been revised thoroughly. Most of the problems have been changed and many more are based upon experimental tables.

UNION-MANAGEMENT COÖPERATION IN THE "STRETCH OUT," Labor Extension at the Pequot Mills. By R. C. Nyman and E. D. Smith; published for the Institute of Human Relations by Yale University Press, New Haven, 1934. Cloth, 6 × 9 in., 210 pp., illus., charts, tables, $3. This publication, the first issued by the Institute of Human Relations, discusses one of the major problems of industrial management, the adjustment of labor to technological changes in an industry. The book presents an interesting, impartial account of the experiences of the Pequot Mills, where an effort was made by the management and the labor union to solve this problem by cooperative study. The successes and failures of the plan are presented clearly and readably.

V.D.I. JAHRBUCH, Die Chronik der Technik. V.D.I. Verlag, Berlin, 1935. Paper, 6 × 8 in., 183 pp., 3.50 rm. This annual is intended to provide the busy engineer with a series of concise reports upon scientific and technical developments during 1934, from which he can obtain a general view of accomplishments. Every important branch of engineering is reported upon by an expert and each report is accompanied by references to the original publications.

VOM WERDEN DER WANDERER-WERKE, 50 Jahre Wertarbeit, 1885–1935. Wanderer-Werke vorm. Winklhofer & Jaenicke Akt.-Ges., Schönau-Chemnitz. By C. Matschoss. V.D.I. Verlag, Berlin, 1935. Paper, 8 × 12 in., 183 pp., illus., maps, 7.50 rm. This handsome volume celebrating the fiftieth anniversary of the Wanderer Works has general interest for the student of the history of engineering, in addition to its account of the development of one great firm. Begun in 1885 as a bicycle shop, bicycle manufacture was successfully undertaken. Further developments added the manufacture of automobiles, milling machines, typewriters, and adding machines. Dr. Matschoss tells the story effectively. The book is profusely illustrated.

WÄRMEWIRTSCHAFT. By H. Netz. B. G. Teubner, Leipzig and Berlin, 1935. Cloth, 6 × 10 in., 94 pp., illus., diagrams, charts, tables, 5 rm. A concise review of the more important questions of heat engineering. These are discussed from a modern point of view, the comparative economy of various possibilities of heat utilization being brought out by numerous curves and tables. Part one discusses power costs in steam plants. Succeeding parts discuss heat conversion, waste-heat recovery, feedwater treatment, piping, and measuring instruments.

WORKING, HEAT-TREATING, AND WELDING OF STEEL, Supplemented with a series of Laboratory Assignments. By H. L. Campbell. John Wiley & Sons, New York, 1935. Cloth, 6 × 9 in., 185 pp., illus., diagrams, charts, tables, $2.25. This textbook, which is planned to assist in the introductory study of certain prescribed phases of the metallurgy of steel, gives a concise account of the principles and practice relating to working, heat-treating and welding. The chemical composition and physical testing of steel, the effects of temperature changes and mechanical working, processes and equipment for working, heat-treating and welding, and methods of preserving steel are discussed. A series of laboratory assignments is appended.

X-RAYS IN THEORY AND EXPERIMENT. By A. A. Compton and S. K. Allison. D. Van Nostrand Co., New York, 1935. Cloth, 6 × 9 in., 828 pp., illus., diagrams, charts, tables, $7.50. This book aims "to present a comprehensive view of the whole field of X-rays, to call attention to those aspects which seem of most fundamental physical significance, and especially to discuss the theory of the phenomena in sufficient detail that their meaning can be appreciated." Students of X-rays and crystal structure will find the book a necessity.

A.S.M.E. FINANCIAL CONDITION IS SOUND[1]

AS A RESULT of unwarranted rumors, inquiries have been received about the financial condition of The American Society of Mechanical Engineers. In reply to these inquiries the following statement is presented.

The Society is in a sound financial position, thanks to the foresight of its officers who in times of more abundant income set aside funds as a reserve to be used for such an emergency as the present depression has proved to be. The best evidence of this financial soundness is the balance sheet at September 30, 1934, certified by Haskins and Sells, our auditors. This balance sheet appeared in the annual report distributed to members of the Society as a supplement to the Transactions for November, 1934. For convenience, it is reproduced herewith.

A study of this balance sheet will show that, in addition to trust-fund investments, the Society possessed on September 30, 1934, securities for which it paid $304,675.14. In addition to these invest-

[1] This is the first in a series of articles on A.S.M.E. problems.

(Reprinted from Transactions for November, 1934, Section Two)

BALANCE SHEET SEPTEMBER 30, 1934

ASSETS

CURRENT ASSETS			
Cash		$ 20,117.65	
Advance Receivable—Committee on Thermal Properties of Steam		4,000.00	
Notes and Accounts Receivable:			
Dues (less reserve for uncollected items)	$10,990.88		
Publications and Advertising (less reserve for uncollected items)	42,293.76		
Miscellaneous	1,534.22	54,818.86	
Inventories:			
Publications for Sale	33,347.40		
Publications in Process	8,228.67		
Supplies	4,095.52	45,671.59	
Securities—At Cost; (Market Value $30,078.75) deposited as collateral to bank notes payable		40,925.14	
TOTAL CURRENT ASSETS			$ 165,533.24
REAL ESTATE MORTGAGE BONDS AND CERTIFICATES—At Cost (Market Value $96,937.50)			
Pledged as Collateral to Bank Note Payable		113,000.00	
Pledged as Collateral to Certificates of Indebtedness		48,750.00	
Unpledged		102,000.00	
TOTAL REAL ESTATE MORTGAGE BONDS AND CERTIFICATES			$ 263,750.00
CASH HELD AS ADDITIONAL COLLATERAL TO CERTIFICATES OF INDEBTEDNESS			319.12
TRUST FUND ASSETS			
Corporate Stocks and Real Estate Mortgage Certificates (Market Value $49,727.75)		118,127.16	
Uninvested Cash		628.32	
TOTAL TRUST FUND ASSETS			$ 118,755.48
PROPERTY FUND INVESTMENTS			
One-fourth Interest in Real Estate and Other Assets of United Engineering Trustees, Inc., Exclusive of Trust Funds		496,948.48	
Office Furniture and Fixtures (depreciated value)		24,277.16	
Library Books		1.00	
Title and Good Will of Engineering Index		1.00	
TOTAL PROPERTY FUND INVESTMENTS			$521,227.64
DEFERRED CHARGES—Society Activities Applicable to Subsequent years			681.46
TOTAL			$1,070,266.94

LIABILITIES

CURRENT LIABILITIES			
Notes Payable:			
Bank (See securities pledged, contra)	$57,500.00		
Others	4,671.63	$ 62,171.63	
Accounts Payable		12,790.55	
Unfilled Commitments		12,520.00	
Custodian Funds		22,728.58	
Reserve for Prepaid Subscriptions		4,000.00	
Accrued Interest on Certificates of Indebtedness		352.12	
TOTAL CURRENT LIABILITIES			$114,562.88
FOUR PER CENT CERTIFICATES OF INDEBTEDNESS, due January 1, 1936, to January 1, 1944. Authorized $125,000			
Issued		$ 36,450.00	
Less: In Treasury		600.00	35,850.00
TRUST FUND RESERVES (balances as shown by books)			118,755.48
PROPERTY FUND RESERVES			521,227.64
RESERVE FOR EMPLOYEES' RETIREMENT ALLOWANCES			21,662.07
DEFERRED CREDIT—DUES RECEIVED IN ADVANCE			35,612.28
SURPLUS (representing excess of income—including initiation fees—over operating expenses and other charges, and subject to provision not having been made for decline of $177,603.89, exclusive of trust fund investments, as of September 30, 1934, in the market value of the Society's investments), PER EXHIBIT B			222,596.59
TOTAL			$1,070,266.94

ACCOUNTANTS' CERTIFICATE

The American Society of Mechanical Engineers:

We have examined your accounts for the year ended September 30, 1934. Under the terms of our engagement, the notes and accounts receivable at September 30, 1934, and collections during the year were not verified by confirmations obtained from the debtors, nor were the quantities of the inventories verified by us.

In accordance with the practise followed by the Society, there have not been included in its accounts nor in the accompanying statements any accruals of interest receivable or payable other than on outstanding certificates of indebtedness.

A separate communication has been addressed to the Society setting forth certain recommendations relating to its accounting procedure and internal accounting control.

In our opinion subject to the foregoing, the accompanying balance sheet and statements of income and expenses and surplus set forth, respectively, your financial condition at September 30, 1934, and the results of your operations for the year ended that date.

[Signed] HASKINS AND SELLS

New York,
November 8, 1934

NOTATION

The yield on trust fund investments for the year based on the book value thereof at the end of the year and on cash income as recorded was 4.28 per cent; on the same basis the yield on the Society's investment in real estate mortgage bonds and certificates was 3.37 per cent.

ments there were other assets. Cash amounted to $20,117.65. The carry-over of dues uncollected was written down to $10,990.88, a most conservative figure. The amounts to be collected from advertising and publications sales were $42,293.76, made up mainly of income expected from Mechanical Catalog and billed only a few days before the close of the fiscal year. The inventories of publications and supplies amounted to $45,671.59 after having been written down to a conservative basis. The miscellaneous items total $5,534.22. The total of these figures is $429,283.24, counting securities at purchase cost, without deducting the estimated decline of $177,603.89 according to market quotations on September 30, 1934, as shown on the balance sheet.

Against these assets are liabilities (as of September 30, 1934) of $186,025.16, of which $62,171.63 represents notes payable, $35,850 long-term Certificates of Indebtedness, and $35,612.28 dues paid in advance. The remainder amounting to $52,391.25 includes accounts payable, unfilled commitments, custodian funds, prepaid subscription reserve, and accrued interest.

With assets at cost as described above of $429,283.24 and liabilities of only $186,025.16, a situation is presented which should be reassuring to members of the Society when they consider the circumstances of the past three years, a brief review of which follows:

In 1931 the total Society income from all sources was $851,777.39. In 1932 the Society suffered an extraordinary drop in income—from both dues and advertising. This drop continued sharply in 1933 and 1934. Strenuous efforts were continually made to reduce expenses. All activities were cut sharply.

In 1931 and 1932 the reduction of income, coming as it did after commitments for expenditures had been made (because the budget is made up four months before the beginning of the fiscal year), resulted in operation at a deficit. Income fell off faster than expenses could be curtailed and it was necessary to resort to the utilization of the securities purposely acquired to meet such an emergency. This could have been done in two ways: The securities could have been sold in a distress market at a considerable loss or used as collateral in negotiating loans for operating expenses. The Society's elected officers decided in favor of the second alternative because the general depreciation in market values of the investments made it unwise to sell the securities. The wisdom of this decision has been demonstrated in the last eighteen months when bonds that cost the Society $60,258 were sold for $61,287. The proceeds of this sale have been used to retire notes held by the bank.

In 1933 the situation was still such that it was unwise to sell real estate mortgages and other investments at a considerable sacrifice. Accordingly, the Council authorized the floating of a long-term loan through the issuance of Certificates of Indebtedness, paying 4 per cent interest. At September 30, 1934, there were outstanding, in the hands of members, Certificates of Indebtedness of a face value of $35,850, the proceeds of the sale having been used to reduce bank notes payable. As a result the bank debt had been reduced to $57,500 on September 30, 1934. This had been further reduced to $44,000 by April 1, 1935.

All of the Society's investments were made in securities legal for trust funds in the State of New York. The fact that New York banks, at a time when liquidity was being desperately maintained, were willing to loan the Society money on these investments as collateral, indicates the soundness of the Society's financial condition. Although at the present time mortgage bonds and certificates on New York real estate, which represent a considerable portion of the Society's investments, do not have a ready market, the soundness of these mortgages is indicated by the fact that in the year ending September 30, 1934, their yield averaged 3.37 per cent.

The complete report of the Finance Committee appeared in the supplement to the November issue of Transactions. The officers of the Society welcome any scrutiny of its financial problems and cooperation in working them out.

The Council has been working hard on Society finances and policy. Last year it kept expenditures below income, decreased the Society's debt and increased its surplus. The budget for the current year is on a balanced basis, income has exceeded estimates and expenditures are within income. From this achievement of financial stability your Council is working forward into a program of better service to the individual member and the profession. Each member is urged to study the Society's problem and make constructive suggestions to his Local Section Executive Committee, to Council members nearest him, to the President, or to the Secretary of the Society.

[Signed]

RALPH E. FLANDERS, *President*, 1934–1935
PAUL DOTY, *President*, 1933–1934
A. A. POTTER, *President*, 1932–1933
CONRAD N. LAUER, *President*, 1931–1932
ROY V. WRIGHT, *President*, 1930–1931
WILLIAM L. ABBOTT, *President*, 1925–1926
WM. F. DURAND, *President*, 1924–1925

WHAT'S GOING ON

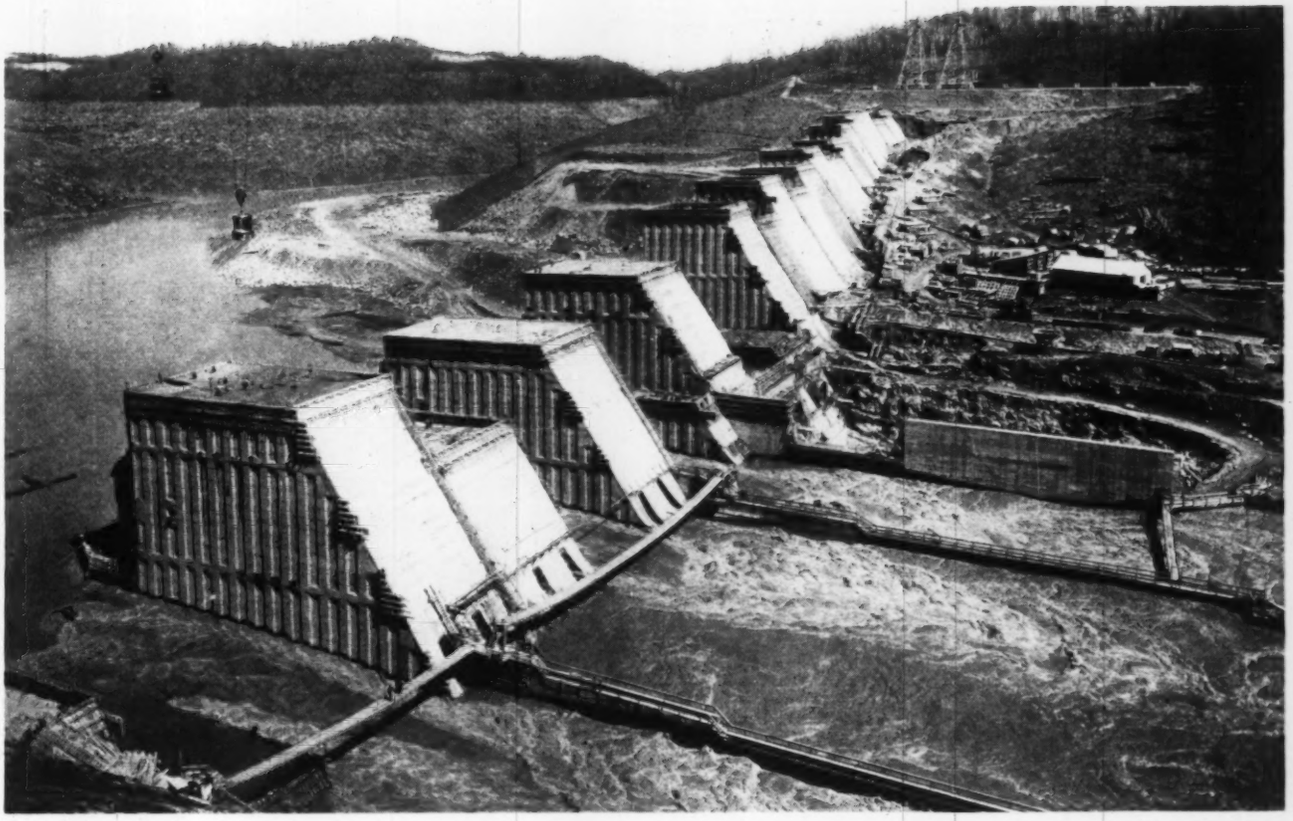
This Month's Authors

THE fourth of the series of addresses to junior engineers delivered this winter at the Baltimore Engineers Club and published by MECHANICAL ENGINEERING for the benefit of all of its readers is by a non-engineer, Roy M. Dorcus. Mr. Dorcus is an associate in psychology at The Johns Hopkins University and assistant editor of the *Journal of Comparative Psychology* and Comparative Psychology Monographs. He has made numerous contributions in the fields of experimental, industrial, and abnormal psychology.

Messrs. Moorhead and Terry, members, A.S.M.E., and serving with the Newport News Shipbuilding and Dry Dock Company, write on the Dnieprostroy hydraulic turbines designed and built in this country for the much publicized Soviet hydroelectric project. Both authors have spent about five months in Russia on the job their paper describes. Both were graduated in 1918, D. G. Moorhead from the University of Michigan, and R. V. Terry from North Carolina College. Mr. Moorhead has been connected with the hydraulic division, New York office, of the company he serves, since 1925. From 1926 to 1928 Mr. Terry was assistant hydraulic engineer, and since 1928 he has been hydraulic engineer of this same company.

Robert R. Tatnall, graduate of Haverford College in 1890, spent the early years of his career in the study and teaching of physics. From 1899 to 1914 he was head of the Physics Department, Syracuse University. He has been engineer of J. E. Rhoads & Sons since 1919.

George B. Karelitz, member A.S.M.E., is a native of Russia where he received degrees in naval architecture and mechanical engineering from the Imperial Polytechnic Institute at Petrograd in 1918. Up to 1922, when he came



NORRIS DAM TO WHICH TRIP WILL BE MADE AFTER A.S.M.E. SEMI-ANNUAL MEETING

to this country, he was a special engineer with the Waterways of Communication. Since 1922 he has been connected with the Westinghouse Electric and Manufacturing Company as research engineer, manager mechanics division, Pittsburgh Research Laboratories, manager transportation, South Philadelphia Works, engineering department, and consulting engineer. Since 1930 he has been associate professor, department of mechanical engineering, Columbia University.

The co-authors of the article on Boiler-Steel Embrittlement have summarized published information on this subject in a report to a subcommittee of the Joint Research Committee on Boiler Feedwater Studies. Everett P. Partridge has been supervising engineer, Nonmetallic Minerals Experiment Station, U. S. Bureau of Mines, Rutgers University, since 1931. Prior to this date he served as associate editor, *Industrial and Engineering Chemistry*, at the same time acting as research engineer in the Department of Engineering Research, University of Michigan. W. C. Schroeder, is Fellow in Boiler Feedwater Studies, Department of Chemical Engineering, University of Michigan, and Detroit Edison Fellow in the study of boiler-scale formation.

William B. Coleman, who contributes the interesting biographical sketch of Walton, founder of the linoleum industry, was graduated in 1924 in Chemical Engineering from the Massachusetts Institute of Technology. Since then he has been working in the development department of Congoleum-Nairn, Inc., during which time his interest in Walton was aroused.

The second of a series of reviews of current economic topics of unusual interest to mechanical engineers prepared by members of the Department of Economics, Massachusetts Institute of Technology, is contributed by B. A. Thresher of that department.

George W. Carter and S. Clark Jacobsen have been engaged in research work at the University of Utah on low-temperature carbonization of the cannel coals of the Rocky Mountain Coal Province. Both are recent graduates of the University of Utah and both are junior members, A.S.M.E.

Plans Well Advanced for 1935 A.S.M.E. Semi-Annual Meeting at Cincinnati

PRECEDING the A.S.M.E. 1935 Semi-Annual Meeting at Cincinnati, June 19–21, the Council of the Society will convene on June 18 at the Hotel Gibson, convention headquarters.

Among the technical sessions a specially timely symposium on Wednesday, June 19, will be devoted to engineering in modern house construction. It will deal with recent developments of prefabricated houses.

The Nominating Committee, A. G. Christie, chairman, will be in session during the meeting, so that members may appear before it in support of candidates for office. The Committee's first session will be at 10:00 a.m., June 19.

Two materials-handling sessions will consist of a group of illustrated talks on the advancement being made in the handling of materials. This part of the program has been specially arranged by the Materials Handling Division and the Cincinnati Section and promises to be of unusual value to production engineers and executives.

Also on Wednesday there will be three papers on education and training for the industries. George A. Seyler, chairman, Committee on Education and Training for the Industries, A.S.M.E., will preside at this session. "Backgrounds of the Cooperative System," is the title of a paper by Dr. Herman Schneider, Dean of the College of Engineering and Commerce of the University of Cincinnati. As the originator of the cooperative system of engineering education, Dean Schneider speaks with authority. Having been associated with cooperative education for over a quarter of a century, he knows it and its possibilities thoroughly. The other two papers relate to apprenticeship systems. William F. Patterson, of Milwaukee, temporarily acting as executive secretary, Federal Committee on Apprentice Training, Washington, D. C., will report on the latest developments of this interesting movement. J. F. Kolb, Director, Department of Industrial Relations, National Metal Trades Association, will discuss apprenticeship systems in the light of the experience of that association. Both these men are experienced speakers, and each has an interesting story to tell.

On Thursday there will be three lectures on color sponsored by the Society's Graphic Arts Division (formerly the Printing Industries Division) and the Graphic Arts Research Bureau. These lectures of general interest will deal with color chemistry, color as light, and color in use. They will include facts about chemistry of color that should be generally understood by engineers and executives, and will be illustrated by dramatic exhibits. They will discuss the steps being taken by color chemists that will affect new vehicles, progress in producing non-fading and alkaline-proof permanent colors for packages, and colors for general printing and for paints. The three lectures will be given by Dr. A. E. Gessler, of the Research Laboratory of International Printing, Inc., Prof. Arthur C. Hardy, of the Massachusetts Institute of Technology, and George L. Welp, color expert.

The Management Division is sponsoring two sessions, one on quality control in manufacturing with a discussion of recording systems, statistical control, inspection control, and effective handling of complaints on quality. The other will be given over to waste elimination in manufacturing.

On Friday the Machine Shop Practice Division will have a session on machine-tool economics which will include a discussion of industrial standards. In the afternoon it is planned to have a session on the Tennessee Valley development covering both its economic and technical features. This will serve as an excellent introduction to the Norris Dam trip.

This trip to Norris Dam, to be held at the close of the meeting jointly with the Society for the Promotion of Engineering Education, will consist of a meeting at Norris, Tenn., on Saturday, June 22, arranged by the Knoxville Section in cooperation with the Tennessee Valley Authority. There will be an afternoon meeting at the Norris Recreation Hall Auditorium with special films and an address on the inspection of the work. This will be followed by dinner and an evening tour of Norris Dam and the town of Norris.

Complete details of the program will be given in the June issue of MECHANICAL ENGINEERING. A total of twenty-four sessions will be held by the Society's professional divisions. The Fuels and Power Division together will hold four sessions; Machine Shop Practice, four; Graphic Arts, four; Management, two; Wood-Industries, two, and Materials Handling, two; others holding single sessions are the Iron and Steel, Education and Training, Railroad, Hydraulics, Process Industries, and Aeronautics Divisions.

Sessions Being Arranged for A.S.M.E. Applied Mechanics Meeting

DR. S. TIMOSHENKO, who is arranging the program for the National Applied Mechanics meeting of the A.S.M.E. to be held at the University of Michigan, Ann Arbor, Mich., June 18 and 19, announces that a technical program of ten to twelve papers is being planned and a dinner meeting on Tuesday night, June 18. Sessions will cover elasticity, plasticity, vibration, and dynamics.

This National meeting will precede and overlap slightly on the Society's Semi-Annual Meeting at Cincinnati, Ohio, but coordination of the two programs has been arranged. The meeting at the University of Michigan will also precede the university's summer session on engineering mechanics in which there are courses especially planned for teachers of engineering mechanics and graduates working for doctors' degrees. Among those giving lectures in the courses are well-known specialists of Europe. An announcement of this session appeared in the April issue of MECHANICAL ENGINEERING, page 270.

A.S.M.E. Oil and Gas Power Meeting at Tulsa, May 8–11

THE program for the six technical sessions at the National Oil and Gas Power Meeting to be held at Tulsa, Oklahoma, May 8 to 11, will cover the latest developments in this field, and in particular the use of power in pipe-line pumping and oil production.

The meeting will be held at the Hotel Mayo and will be under the auspices of the Oil and Gas Power Division and the Mid-Continent Section of the A.S.M.E.

Of special interest among the papers being presented are those on fuel-oil characteristics and central power plants transmitting power to wells. The formal technical papers will be made available by the Division and Section in cooperation with the *Oil and Gas Journal* and *Diesel Power*.

A detailed program follows:

WEDNESDAY, MAY 8

9:30 a.m. Registration

11:00 a.m. ***Opening Session***

Chairman: Harte Cooke, Mechanical Engineer, McIntosh Seymour Co., Auburn, N. Y.

Experiences With High-Speed Diesel Engines in Pipe-Line Service, by J. B. Harshman, Stanolind Pipe Line Co., Tulsa, Okla.

2:30 p.m. ***Diesel-Fuel Session***

Chairman: Lester M. Goldsmith, Atlantic Refining Co., Philadelphia, Pa.

Characteristics of Diesel Fuel Oil, by W. F. Joachim, Atlantic Refining Co., Philadelphia, Pa.

THURSDAY, MAY 9

9:30 a.m. ***Central-Power-Plant Session***

Chairman: H. F. Brindel, Gypsy Oil Co., Tulsa, Okla.

Central Generating Plants Transmitting Power Electrically to Wells, by George Bays, Stanolind Oil & Gas Co., Tulsa, Okla.

Central Power Plants Transmitting Power Mechanically to Wells, by Austin Allen, Phillips Petroleum Co., Bartlesville, Okla.

12:00 m. Busses leave hotel for inspection trip to the Hominy Pumping Station of the Stanolind Pipe Line Co.

FRIDAY, MAY 10

9:30 a.m. ***Morning Session***

Chairman: W. H. Carson, University of Oklahoma, Norman, Okla.

Central Power Plants Transmitting Power Pneumatically to Wells, by Paul D. Cornelius, Sullivan Corp., Tulsa, Okla.

Diesel and Gas Individual Well-Pumping Units, by Glenver McConnell, Shell Petroleum Corp., Tulsa, Okla.

Insurance of Diesel Engines, by H. J. Vandereb, Hartford Steam Boiler Inspection & Insurance Co., Hartford, Conn.

2:00 p.m. ***Afternoon Session***

Chairman: Ralph Miller, Chief Engineer, Ingersoll-Rand Co., Phillipsburg, N. J.

Experiences With Fuel-Injection Equipment in Oil-Field Service, by Carl Behn, United American Bosch Co., Springfield, Mass.

Compressed-Air Transmission With Diesel Locomotives, by Carl Bjornsson, Engineering Department, Clark Bros., Olean, N. Y.

6:30 p.m. Informal Dinner

SATURDAY, MAY 11

9:30 a.m. ***Morning Session***

Chairman: H. P. Porter, Chairman, Mid-Continent Section, A.S.M.E.

Informal Discussion of:

- Experience With Explosions in Air Piping Due to Fuel Leaking Into Air System
- Air-Compressor Explosions and Methods of Correction
- Causes and Correction of Corrosion of Bearings and Crankshafts
- Possibility of Control of Combustion Pressures in Solid-Injection Engines to Secure Smoother Operation and to Reduce Stresses on Working Parts.

Royal Society of Arts Offers Prizes for Inventions and Essays

AT THE request of G. K. Menzies, secretary, Royal Society of Arts, John Street, Adelphi, London, England, the following notice of the Thomas Gray Memorial Trust Prizes, offered in 1935 for the improvement and encouragement of navigation, is presented.

The Council of the Royal Society of Arts offers the following prizes:

(1) PRIZE FOR AN INVENTION

A prize of £100 to any person who may bring to their notice an invention, publication, diagram, etc., which, in the opinion of the judges appointed by the council, is considered to be an advancement in the science or practice of navigation, proposed or invented by himself in the period January 1, 1930, to December 31, 1935. Entries which have already been considered by the judges in the years 1930–1934 are not eligible for further consideration unless they have since been materially modified.

In the event of more than one such improve-

ment being approved, the council reserve the right of dividing the amount into two or more prizes at their discretion. Competitors must forward their proofs of claim on or before December 31, 1935, to the Secretary, Royal Society of Arts.

(2) PRIZE FOR AN ESSAY

A prize of £100 for an essay on the following subject: "Modern Navigational Appliances."

(1) Appliances made possible by electricity on board, e.g., Wireless D.F., Echo Soundings, Gyroscope, etc.

(2) Appliances not depending on electricity, e.g., Range Finding, Sounding Machine, Compass, etc.

Candidates are expected to deal with both sections. They should write from a practical point of view and give their views on the advantages and disadvantages or failures (if any) of modern electrical aids to navigation, based if possible on personal experience.

Competitors must send in their essays not later than December 31, 1935, to the Secretary, Royal Society of Arts.

The essays must be typed in English. They must be sent in under a motto, accompanied by a sealed envelope enclosing the author's name, which must on no account be written on the essay. A breach of this regulation will result in disqualification.

Both competitions are open to persons of any nationality, but, in the case of the essay competition only, competitors must be past or present members of the seafaring profession.

The judges will be appointed by the council.

The council reserves the right of withholding a prize or of awarding a smaller prize or prizes, if in the opinion of the judges no suitable invention or essay is submitted.

The council also reserves an option on the copyright of the successful essay or essays, but does not claim any rights in respect of any invention to which a prize may be awarded.

Consumers-Goods-Industry Investigation to Enlarge Its Work

DURING March cards were sent to members of the A.S.M.E. Metropolitan Section, New York, inquiring if they were interested in participating in the Junior Group investigation of the consumers-goods industries for the purpose of uncovering new opportunities for engineers (see MECHANICAL ENGINEERING, March, pp. 198–199). The replies showed that the junior members are actively interested in the project. The committee feels that it should, in response to the interest expressed by the number of replies, increase its scope by subdividing the investigations so that a greater number of men may participate.

In order that a larger group of men may be accommodated, future meetings will be held every first and third Monday of the month at the Engineering Societies Building. Any one who is interested is invited to attend the meetings as a visitor or as a participant. The committee would appreciate an early response from those who wish to join in the work so that the industries not already assigned may be allocated to them.

Working on the project is not restricted to those who are now engaged in the consumers-goods industries, or to those who plan to enter these fields, but it is open to all young engineers. Men who are primarily interested in the capital-goods industries can also obtain benefits by working on the investigation.

The method of the investigation is such that every man will not only obtain a greater knowledge of a specific industry but also a greater understanding of the whole group of consumers-goods industries. So that each man can obtain the greatest personal benefit from the investigation, the committee assigns to each worker, for study, a separate industry. The man is responsible for collecting all the data pertinent to this industry. Then, when he has acquired a general picture of the industry, he presents the data collected according to the procedure, to the meeting. The group as a whole analyzes and comments upon the data under the guidance of the investigator of the industry under study. Thus as each industry is studied the group as a whole increases its knowledge of the consumers-goods industries, and each member has a specialized knowledge of a specific industry.

The work is being carried on under the direction of a committee of the Metropolitan Junior Group known as the Committee for the Investigation of New Industrial Fields, of which Eugene Koenig is chairman. Subcommittee chairmen are Joseph Nelson and William J. McLarney.

Officers of National Engineering Societies to Hold Joint Meeting May 20

OFFICERS and directors of the national societies of civil, mining and metallurgical, mechanical, and electrical engineers, and of their several jointly sponsored functional organizations will all meet together for dinner Monday, May 20, at the Engineers' Club in New York, according to plans recently announced by United Engineering Trustees, Inc., acting for the societies in sponsoring the proposed meeting. Harvey N. Davis, President, Stevens Institute of Technology, will act as toastmaster. This is the first time in the history of the engineering societies that any such meeting has been undertaken and it is considered to be an important and significant step toward the establishment of a broader and clearer understanding of the scope and significance of the work carried on jointly by the several participating societies.

A wide variety of technical and other activities of importance to every branch of the engineering profession is now, and for many years has been, carried on by the agencies jointly created and sponsored by the engineering societies: United Engineering Trustees, Inc., and its two departments, The Engineering Societies Library and The Engineering Foundation; American Standards Association; the Division of Engineering and Industrial Research of the National Research Council; Engineering Societies' Employment Service, and Engineers' National Relief Fund; American Engineering Council; and, more recently, Engineers' Council for Professional Development. The activities, ideals, and procedures of each of these agencies will be described and explained concisely by society representatives who have been long associated with the work in each case.

Plans for this joint dinner meeting have grown out of discussions between the United Engineering Trustees and the secretaries of the Founder societies that began in January. The committee in charge of the affair includes Dr. Alfred D. Flinn, director of The Engineering Foundation, chairman; H. V. Coes, president of United Engineering Trustees, Inc., honorary chairman; George T. Seabury, secretary, American Society of Civil Engineers; A. B. Parsons, secretary, American Institute of Mining and Metallurgical Engineers; C. E. Davies, secretary, American Society of Mechanical Engineers; H. H. Henline, Secretary, American Institute of Electrical Engineers; and John Arms, secretary, United Engineering Trustees, Inc.

Annual Report of Engineering Foundation

THE 1934 Annual Report of The Engineering Foundation, Ambrose Swasey, founder, established in 1914 for the Founder Engineering Societies, was published in April.

During the year the twentieth anniversary of the Foundation was appropriately celebrated, as was previously reported (see MECHANICAL ENGINEERING, December, 1934, page 768).

Capital funds of the Foundation are reported as endowments having a total book value, December 31, 1934, of $882,000. The net income from endowment was $40,000, in 1934. The E. H. McHenry bequest in the hands of executors until the life of two life beneficiaries at probate of will in 1931, is approximately $400,000.

"Activities in 1934," states the report, "included investigations of concrete and reinforced-concrete arches, earths and foundations and plastic properties of concrete, in the civil engineering field; critical review of the world's literature on alloy irons and alloy steels since 1890, and barodynamic research, both sponsored by the American Institute of Mining and Metallurgical Engineers; in cooperation with committees of The American Society of Mechanical Engineers, studies of effect of temperature on properties of metals, cutting of metals, thermal properties of steam, mechanical springs, riveted joints, and wire rope; under sponsorship of the American Institute of Electrical Engineers and electric welding research on pure iron electrodes."

The Engineering Foundation whose headquarters are the Engineering Societies Building, New York, devotes its resources to human as well as technical aspects of engineering problems of wide interest. It aids activities for "the furtherance of research in science and engineering and the advancement in any other manner of the profession of engineering and the good of mankind."

Engineering Foundation News

AMONG activities of The Engineering Foundation of interest to mechanical engineers reported since January 1, 1935, are the following:

Work began January 2 on research on the plasticity of metals under the leadership of Dr. A. Nadai, member, A.S.M.E., an international authority, in cooperation with University of Pittsburgh and a number of industrial companies.

Research Procedure Committee, D. Robert Yarnall, chairman, and Iron Alloys Committee, George B. Waterhouse, chairman, were reappointed. Education Research Committee, Harvey N. Davis, chairman, was discharged, on request, with special appreciation for producing the booklet, "Engineering—A Career, A Culture," and for other valuable services. Appointment of a Welding Research Committee was authorized, if a plan for coordinated welding research and nominations for members be received from the A.I.E.E. and associated organizations. A Platform and Program Committee was appointed, Otis E. Hovey, chairman.

"Principles of Phase Diagrams," the fifth Alloys of Iron book was issued in March. It explains and illustrates the thermodynamic principles underlying the behavior of a system of metals or other substances under changing conditions of temperature, composition, and pressure. It is a tool book for metallurgists in industry and a textbook for colleges.

Progress has been made by a planning committee toward stating a coordinated, comprehensive project, arranging a conference of representatives of interested organizations and industries, and selecting men to be nominated for members of the proposed Welding Research Committee. Members of the planning committee are F. M. Farmer, chairman, Chairman of Research Committee of A.I.E.E., Dr. D. S. Jacobus, president, American Welding Society, Prof. C. A. Adams, director, American Bureau of Welding.

Officers elected at the annual meeting for period ending September 30, 1935: Chairman, H. P. Charlesworth, Vice-Chairman, D. Robert Yarnall; other members of Executive Committee are J. V. N. Dorr, Edwards R. Fish, and Otis E. Hovey; and the director and secretary, Alfred D. Flinn.

Representatives of the A.S.M.E. on The Engineering Foundation are A. E. White, D. Robert Yarnall, and W. H. Fulweiler.

Conrad Matschoss Resigns as Director, V.D.I.

ON JANUARY 1, 1935, Conrad Matschoss, honorary member, A.S.M.E., resigned as director of the Verein deutscher Ingenieure in order to devote himself more intensively to his historical work. The president of the Verein deutscher Ingenieure has assigned Dr. Matschoss the special duty of promoting friendly relations with engineers in other countries.

V.D.I. Honors Elihu Thomson

ON THE occasion of his 82nd birthday March 29, Dr. Elihu Thomson, Honorary Member, A.S.M.E., holder of more than 700 patents in the United States and father of alternating-current distribution, was awarded the medal of honor of the Verein Deutscher Ingenieure, the outstanding award of the German engineering profession. The medal of honor has previously been conferred on but five non-Germans, only one of whom was an American—the late Dr. Calvin W. Rice. "Professor" Thomson, as he is most frequently called in his profession, is the first American to be awarded any German honorary medal or degree since the organization of the new government.

Presentation of the medal was made in Boston by Herr Von Tippelskirch, German consul general in that city, on the occasion of a meeting of the board of directors of the General Electric Company, of which Dr. Thomson was one of the founders. A.S.M.E. representatives at the ceremony were Prof. James A. Hall, member of Council, Past-President Charles T. Main, Prof. Lionel S. Marks, and Mr. I. E. Moultrop.

At the services in Berlin were U. S. Ambassador William E. Dodd, Ernst F. S. Hanfstaengel, foreign press chief of the Nazi party, and President Dr. Hermann Buecher of the Allgemeine Elektricitäts Gesellschaft who were addressed by President H. Schult of the Verein, who said: "We German engineers who, with our leader, believe that this world can only be freed from the great troubles of the world crisis by honorable, peaceful, and fruitful work, honor Elihu Thomson, the inventor and research scientist. He is the great cooperator.

The citation with the medal read as follows: "On Elihu Thomson, the great pioneer in the realm of engineering, the inventor and research scientist, the promoter of cooperation among engineers, there is conferred, on the anniversary of his 82nd birthday, the V.D.I. medal of honor."

The medal was accepted on behalf of Professor Thomson, whose health confined him to his home in Swampscott, Mass., by E. W. Rice, Jr., who is an old colleague of the recipient, is a former president of General Electric, and is now the honorary chairman of its board of directors.

Professor Thomson, besides being one of the founders of the General Electric Company, is known among scientists all over the world for his research and inventions in the electrical field. In addition to being the father of alternating-current distribution and the grantee of more than 700 U. S. patents, he was a pioneer in arc-lighting and wireless-telegraphy development.

He has received so many honors and awards for his achievements that it is difficult to list them all. He is the only scientist in the world possessing all three of the following outstanding awards of English scientific and engineering institutions: the Faraday medal, the Kelvin gold medal, and the Hughes medal of the Royal Society. Other honors include the Franklin medal, the John Scott medal, the John Fritz medal, the Paris Exposition Grand Prix, the Rumford medal, the Elliott Cresson medal, and the first Edison medal of the A.I.E.E. He is a Chevalier and Officer of the French Legion of Honor and an honorary member of the Royal Institute of Great Britain.

Because of the fact that Germany is today in need of gold to support its currency, the medal is of bronze but is embedded in an especially designed case encrusted with amber, a material referred to in Germany as "German gold."

Meetings of Other Societies

S.P.E.E. IN ATLANTA, JUNE 24 TO 27

THE 43d Annual Meeting of the Society for the Promotion of Engineering Education will be held at the Georgia School of Technology, Atlanta, Ga., June 24 to 27.

A.S.H. & V.E. IN TORONTO, JUNE 17 TO 19

The 1935 Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers will be held at the Royal York Hotel, Toronto, Ontario, Canada, June 17, 18, and 19, 1935.

GEAR MANUFACTURERS IN WILKINSBURG, MAY 14 AND 15

The American Gear Manufacturers Association will hold its annual meeting at the Penn-Lincoln Hotel, Wilkinsburg, Pa. (Pittsburgh), May 14 and 15, 1935.

SPECIAL LIBRARIANS' CONVENTION, BOSTON, JUNE 11 TO 14

The Special Libraries Association will hold its 27th annual convention in Boston, June 11 to 14, with headquarters at Hotel Statler. The Science-Technology Group, which, with a membership of over 200, is one of the most active and alert, will hold three meetings.

A.E.C. News From Washington

WORK-RELIEF BILL

THE engineering nature of the program to be based on the $4,888,000,000 work-relief bill, recently signed by President Roosevelt, becomes evident from the type of projects earmarked in the bill. The $4,880,000,000 represents an appropriation of 4 billions plus the release of approximately 880 millions from past appropriations. The latter sum is to be used mainly for continuance of relief through June 30 and for repayment of PWA funds temporarily placed in relief channels while passage of the bill hung fire. Allocation of the 4 billions is as follows:

Highways; roads; grade crossings	$ 800 millions
Rural rehabilitation and relief in stricken areas; water conservation; trans-mountain water diversion; irrigation; reclamation	500 millions
Rural electrification	100 millions
Housing	450 millions

(Continued on page 338)

INTERNAL PARTS (without frame) can be incorporated into design of any machine—either *inside* or *outside* the frame of the machine.

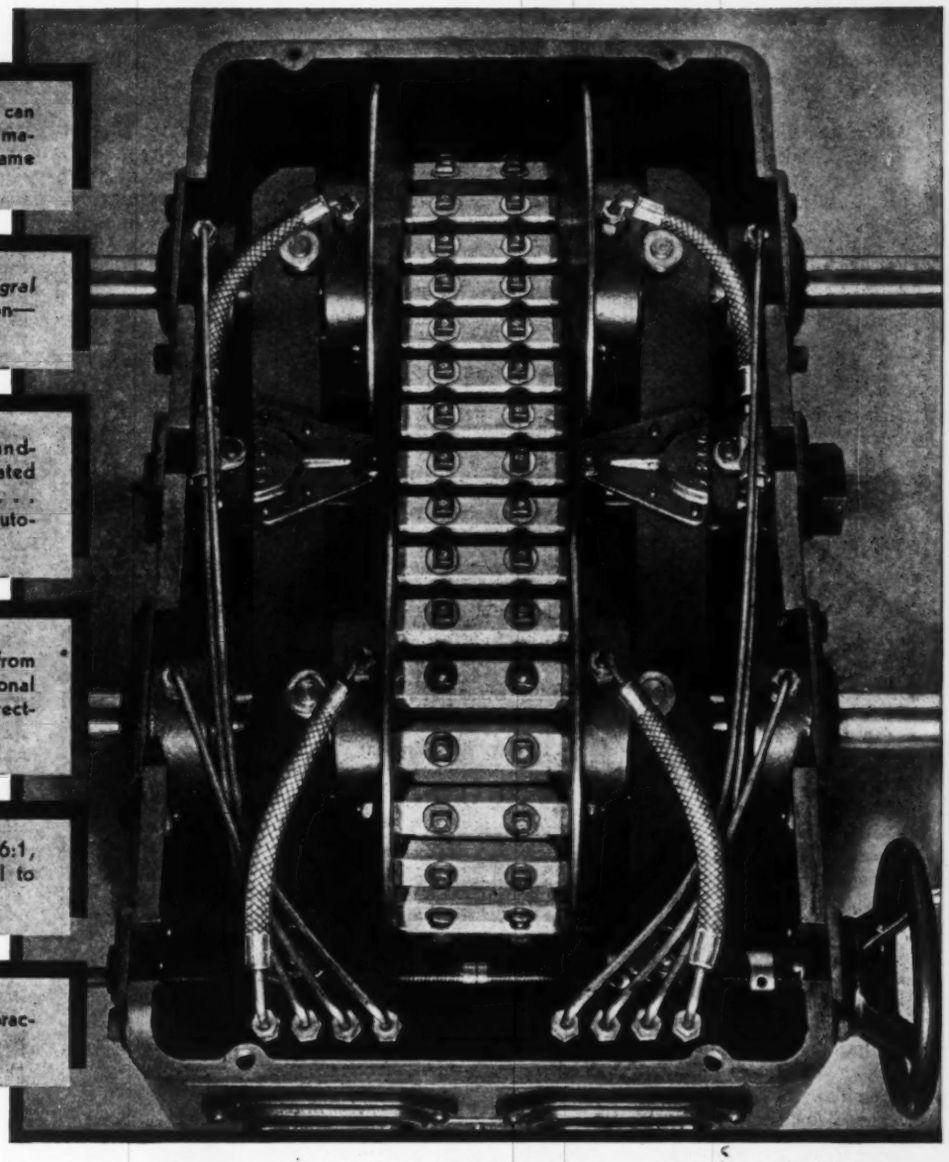
MOTOR MOUNTING may be *integral* with any type REEVES Transmission—open, enclosed, horizontal, vertical.

CONVENIENT CONTROL— handwheel and speed indicator can be located where most *accessible* to operator . . . Also, electric-remote and entirely automatic controls.

DRIVING CONNECTIONS, to and from the REEVES, may be of any conventional type—gears, V-belt, chain, etc., or direct-connected.

SPEED RANGES from 2:1 up to 16:1, inclusive, in 14 sizes from fractional to 125 h. p.

ANY POSITION of installation is practical . . . upright, horizontal or angle.



Top view of Enclosed Design REEVES Transmission with cover removed to illustrate convenient system of "centralized" force-feed lubrication.

TO SIMPLIFY THE DESIGNER'S PROBLEM

. . . many adaptable speed control units in one complete line

● "ONE of the most important problems in the development of production machinery is that of making the machine thoroughly flexible in speed control", wrote the editor of a widely-read engineering magazine recently.

To simplify this problem and to make it easy to equip *every* new machine for efficient performance under *every* operating condition, REEVES provides the Variable Speed Transmission in many designs, types, sizes. This adaptability is an outstanding reason why the REEVES is used by builders of more than 1100 different makes of machines.

For example, the internal operating mechanism, without frame, may be incorporated right into the frame or base of the driven machine. Wide range of enclosed designs, open designs—and vertical designs, for saving valuable horizontal space. Units with compact motor mounting . . . Units substituting *your own* support bearings. Even lubrication, not only of Transmission but of entire driven machine, may be centralized in one accessible panel.

The designer who adopts the REEVES is freed from limitations imposed by speed control units requiring special mountings and a fixed amount of space. He can plan his machine from the most practical engineering standpoints and *know* that it is equipped for most efficient and lowest-cost production . . . Let REEVES engineers counsel with you on the best application for your needs.

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(5-35) Also send copy of Catalog G-99.

Assistance for educational, professional, and clerical persons	300 millions
Civilian Conservation Corps	600 millions
Loans and grants to states, municipalities, etc., not less than 25 per cent of each loan or grant for work	900 millions
Sanitation; prevention of soil erosion; prevention of stream pollution; sea-coast erosion; reforestation; flood control; rivers and harbors; miscellaneous	350 millions
Total	$4000 millions

Not to exceed 20 per cent of the 4 billions may be used to increase any one or more of the items.

The items may be somewhat misleading in that they represent classes of work rather than functional divisions of the program. Any given item, practically speaking, may be split between several operating agencies of the Government.

To reclassify, the three headings, relief, agriculture, and public works, are more descriptive. Administrator Hopkins takes a dominant role and will handle work-relief activities touching almost every imaginable phase of human activity. Secretary Tugwell again takes prominence in his supervision of agricultural phases, including rural electrification and soil erosion control. Secretary Ickes is still in with work of the PWA type but he is shorn of some of his functions and is less of a public-works czar than before. Bureau of Public Roads will handle highway allotments, the largest single phase. Admiral Peoples has public buildings. An advisory committee headed by General Wood will represent industry. CCC is strengthened and remains a sort of labor pool for almost any phase of the program. Just where housing fits is not yet clear but the rural rehabilitation phase will be an important item. The president controls all and has broad powers in shaping and reshaping the program.

General policies remain much as set in the President's first message to this Congress, giving preference to useful projects employing a high ratio of direct labor with some prospect of self-liquidation. Wages are to be more than doles but less than regular pay scales—the security-wage idea. Competition with private industry is to be avoided. A shift of employables from cash relief into work-relief projects will be undertaken as speedily as possible, focusing on the centers of unemployment, so that the present work-relief figure will be raised from $2\frac{1}{2}$ to $3\frac{1}{2}$ million persons, while unemployables are thrown to the states. The hope is to carry through until private employment, stimulated perhaps by the indirect effects of the program, takes up the load.

Above all, employment and social welfare are the main principles and those in control are known "Liberals." But politics is powerful. There is an election next year. Much that is done in the selection of projects and personnel will be a compromise between the social view and the political view.

Further details are confused as the plans of Federal agencies are re-aligned under the bill. News is full of conflicting rumors. Discount nine-tenths and disbelieve the other tenth unless based upon executive orders from the President. As soon as the set-up really is known, the American Engineering Council will report it.

American Engineering Council, the representatives of its member societies, and other groups of organized engineers are actively negotiating in Washington with regard to the engineers' part in the vast program.

U. S. CHAMBER OF COMMERCE MEETING

Durable goods and housing will be the subject of a round-table conference in Washington April 30 at the annual meeting of the U. S. Chamber of Commerce, arranged through the suggestion of Alonzo J. Hammond, vice-president of A.E.C., who is a member of the Chamber's Committee on Relief Activities, and with the cooperation of A. P. Greensfelder, vice-chairman of the Construction and Civil Development Department Committee of the Chamber. Topics and speakers will be: "Equipment Needs of American Industry," John W. Leary, president, Machinery and Allied Products Institute; "Release of Capital Funds for Durable-Goods Revival," speaker to be announced; and "A Business View of the Government Housing Program," by Dr. G. A. Nichols, president, G. A. Nichols, Inc., Oklahoma City. Secretaries of member organizations of Council have been invited to attend and to be prepared to enter the discussion.

L. V. Reese to Assist F. M. Feiker on American Engineering Council

L. V. REESE, who has been handling Rural Industrial Communities in the Rural Rehabilitation Program of the Federal Emergency Relief Administration, has resigned to become assistant secretary of the American Engineering Council in Washington. He has also served the FERA as executive secretary of the District of Columbia Rehabilitation Corporation and as planning engineer for the Texas Relief Commission.

In his new position, Mr. Reese will assist the executive secretary, Frederick M. Feiker in carrying out the enlarged program of the American Engineering Council voted at its recent annual meeting as a service agency for relating the organized engineering professions to national affairs in the public interest. He will serve also as a liaison officer between the Federal agencies and organized national, state, and local professional engineering societies, by which 222 localities are coordinated.

His assistance will be available both to Government agencies and to the member organizations of American Engineering Council, to make effective the engineers' contribution in planning and executing the $4,880,000,000 work-relief program, almost every phase of which is an engineering job.

Mr. Reese, who is 43, was educated in civil engineering at the University of Texas and in mechanical, metallurgical, and industrial engineering at Columbia and New York Universities. His experience in engineering and executive capacities has been extensive. Prior to his service with Federal agencies he was engaged in the industrial, public-utility and construction fields. He was assistant to the president and manager of the research division of the American Foundry and Machine Company, vice-president and general manager of the Erie City Iron Works, and chief engineering executive of the American Metal Company and the United States Metals Refining Company. During the War, he was assistant supervising constructing quartermaster on cantonment work for the U. S. Army. For several years before the War he managed his own engineering business, doing civil and industrial engineering and the construction of industrial plants, public buildings, and utilities.

E.C.P.D. Second Annual Report Now Available

DEVELOPMENTS in the cooperative program of engineering societies, educators, and representatives of state licensing boards looking toward the improvement of the engineering profession and the enhancement of the status of its members are recorded in the Second Annual Report of the Engineers' Council for Professional Development, published on April 15.

The report, copies of which may be obtained at the headquarters of the Council, 29 West 39th Street, New York, N. Y., at 25 cents each, is a pamphlet of 44 pages and includes four individual reports of the Council's principal committees on student selection and guidance, engineering schools, professional training, and professional recognition.

C. F. Hirshfeld, director of research, Detroit Edison Company, and C. E. Davies, secretary, of The American Society of Mechanical Engineers, acting, respectively, as chairman and secretary of the Council for 1934, call attention in the main report to the progress made during the year. The seven participating bodies approved the recommendation that the E.C.P.D. be established as an accrediting agency for schools of engineering. Two of the participating societies, the American Society of Civil Engineers, and The American Society of Mechanical Engineers approved in principle a definition of an engineer, proposed by the Council, and standard grades of membership in engineering societies, a recommendation of the Council. Another participating body, the National Council of State Boards of Engineering Examiners, approved the definition.

In addition to the reports of the four major committees, the main report also includes the Charter and Rules of Procedure of the E.C.P.D., the verbatim statement of five policies previously adopted by the E.C.P.D., and the complete personnel of the Council and all of its committees. The report is thus a complete and authoritative source of information on the work and organization of this body.

The Engineers' Council for Professional Development is a Conference of Engineering

(*Continued on page 340*)

This name plate

gives capacity in horsepower according to the formula established by the American Gear Manufacturers Association. A nameplate of this character will be affixed as soon as possible to the products of the companies whose names are listed below:

An important announcement to users of SPEED REDUCERS

The American Gear Manufacturers Association has unanimously adopted as Recommended Practice rating formulas for determining the capacity of any standard helical or herringbone geared speed reducer or any heavy duty worm geared speed reducer. These Formulas are the result of several years of experimental work and mathematical research by a Committee of Engineers especially appointed for the purpose by the A. G. M. A.

Previously much confusion and lack of uniformity existed in the rating of speed reducers which was obviously detrimental to the interests of the purchaser. The A. G. M. A. Ratings now adopted solve this vital problem. They are simple to apply, and are equally applicable for normal or for severe service, it being necessary merely to apply the correct service factor as given in tables when selecting a speed reducer for any individual purpose.

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THE FALK CORPORATION
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FOOTE BROS. GEAR & MACHINE CO.
5301 So. Western Blvd. — Chicago, Illinois

FOOTE GEAR WORKS, INC.
1301 S. Cicero Avenue — Cicero, Illinois

THE HORSBURGH & SCOTT CO.
5114 Hamilton Ave. — Cleveland, Ohio

W. A. JONES FOUNDRY & MACHINE CO.
4401 W. Roosevelt Road — Chicago, Illinois

LINK-BELT COMPANY
910 S. Michigan Ave. — Chicago, Illinois

PACIFIC GEAR & TOOL WORKS, INC.
1035 Folsom Street — San Francisco, Calif.

PALMER-BEE COMPANY
Detroit, Michigan

PHILADELPHIA GEAR WORKS, INC.
Erie Ave. & G. Street — Philadelphia, Pa.

WATSON-FLAGG MACHINE CO.
Paterson, New Jersey

WESTERN GEAR WORKS
9th Ave. So. and King St. — Seattle, Wash.

WESTINGHOUSE ELECTRIC & MFG. CO.
Nuttall Works — Pittsburgh, Pa.